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ERRATA.

Page 47 line 22 *for* "striped" *read* "stripped"
Page 78 footnote *for* "Sowing" *read* "Saving"

EDUCATION IN ITS RELATION TO AGRICULTURE.*

BY

BERNARD COVENTRY, C.I.E.,

Agricultural Adviser to the Government of India and Director of the Pusa Agricultural Research Institute.

"I am no educator, no teacher; I have made no psychological study of young people from an educational point of view, nor of the different methods of teaching suited to different ages, no statistical investigation of the influence of particular curricula in training the mind or furnishing it with useful information. I have, in short, neither made contributions to the science of education nor practised the art ....I can speak only as a member of the general public—not as an expert................not that I regard the view of the general public as unimportant................ The general public must, as all will admit, decide what is to be spent on education or, more strictly, on schools and colleges and professional educators, out of both public and private income—it is for them to decide on its relation to other social and family needs. But the concern of the public with education is not merely financial and administrative. It is more intimate than that. For education is not a subject like physics or chemistry on which only an expert has a right to an independent view. There are, no doubt, aspects of it of which only the expert can properly judge, there are experiments in it which only the expert can advantageously try, and there are, of course, departments of it in which the opinion of the expert is indispensable. But without depreciating either the science and art of education, it is clear that when we take education

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* A paper read at the Third Indian Science Congress, Lucknow, 1916.

in its widest sense it concerns everybody and almost everybody is bound to have views about it."

These words were spoken by no less a person than Mrs. Henry Sidgwick in her address as President of the Section on Educational Science at the recent meeting of the British Association at Manchester.

I feel like Mrs. Sidgwick that I am "no educator and no teacher" and that an apology or at least an explanation is required from me for troubling you to-day in a subject on which I am not an expert. But when we have it on such an authority as Mrs. Sidgwick that education "concerns everybody and almost everybody is bound to have views about it" I feel I have a measure of sanction for imposing my views upon you. I do not propose, however, to make full use of this sanction and tell you all I think about education, but I propose to restrict my remarks to education in its relation to agriculture and further with the exception of an introductory statement dealing with a few facts, I do not propose to say much on the education of youth, but of that of the adult. You will probably all admit that this is quite a novel and peculiar way of dealing with the question of education, but I trust you will find it none the less interesting and instructive. I should like to say before I go any further that I claim no credit for the ideas I shall place before you. They all come from America and, like every thing that comes from that wonderful country, they are exceedingly "cute" and practical and in my opinion are eminently applicable to India.

The population of British India comprises over 255 million souls. Of this vast multitude 80 per cent. or over 200 millions, that is to say, 4 in every 5 are dependent on agriculture. Any educational system therefore which does not take into consideration the relationship it should bear to agriculture is likely to be at a disadvantage. It is on the importance of this aspect of the educational problem I intend to address my remarks. Now out of the whole population, 7½ millions or about 3 per cent. are scholars, though 15 per cent. or 36 millions are of the school-going age. Thus only 20 per cent. of those of the school-going age receive any

education at all. Of these $7\frac{1}{2}$ million scholars, about 1 million proceed to secondary education and about 40,000 reach a University career.

In judging of these figures in relation to the agricultural industry it should be borne in mind that the percentage of scholars is much higher in the urban than in the rural areas and also that a very large number of rural scholars never get more than a mere smattering of the most elementary education; so that educational efficiency in rural areas is very much lower than the official returns of general education would indicate. I may appropriately refer here to a small brochure entitled " A Policy of Rural Education " by Mr. S. H. Fremantle[1], the Collector of Allahabad, which has quite recently been published and which is well worthy of perusal. He complains how both in urban and rural schools education is too literary and how primary schools are worked for the benefit of that small section which can afford a secondary education and not in the interests of the overwhelming majority of agriculturists, most of whom abandon their studies after a few months. I think Mr. Fremantle is right. It means that very few indeed of the agricultural population get any education at all, and that, as a class, it can be put down as almost illiterate. The authorities have not been ignorant of these facts, and it is not from want of trying to improve matters that things are at such a low ebb. Much has been done in recent years to improve our system of education, especially in its relation to agriculture and the subject may be said to have received an unwonted measure of attention. In 1901 an important conference was held at Simla presided over by Lord Curzon which led to a complete overhauling of the existing educational machinery. A policy of reform was then started, the vitalizing influence of which is felt to this day. A department of education was created with a member of council in charge. Money grants were increased and they have still further increased, as a result of keen interest taken by the present Viceroy Lord Hardinge who has made education a special object of his attention. Thus the total expenditure which

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1 " A Policy of Rural Education " by S. H. Fremantle, C.I.E. Newman, Calcutta.

in 1901 was 4 crores, to-day is over 10 crores. The number of pupils in 1901 was $3\frac{3}{4}$ millions, to-day it is $7\frac{1}{2}$ millions. Interest has been stimulated in every quarter and expansion is noticeable in every branch.

Agricultural and rural education have had quite a fair share of attention, and the need which exists for connecting the teaching of the schools with our chief industry has been and still is fully recognized. I therefore do not complain of want of endeavour. But it cannot be said that these efforts have been crowned with the success one would have wished. But if we have to admit failure, whether complete or partial, we have gained considerably by the discussions which have resulted and by the light which has been thrown on the difficulties inherent in the problem.

The occasion when agricultural education first seriously engaged the attention of Government and the people was in 1904, when the policy for improving the agricultural industry was started by Lord Curzon. At first it was the intention to restrict efforts to improving the industry itself, but later, influenced no doubt by the examples of advanced schemes abroad, the Government elaborated a policy under which not only research and experiment, but agricultural education proper, formed an important and integral part. Large sums of money were devoted to the erection of agricultural colleges in nearly all the Provinces. Syllabuses were prepared by the Board of Agriculture and the Colleges were empowered to grant a diploma of Licentiate of Agriculture. At first signs of success were not wanting. Candidates freely offered themselves for admission and there was found no difficulty in filling the colleges. However, as time rolled on, a decline in admissions became perceptible until the year 1913 when, in some colleges, the position became acute and the matter was brought up for consideration before the Board of Agriculture. The proceedings of the Board in that year indicate the general failure of the schemes drawn up in 1906 and 1908, and we find it expressed that the courses were found not to be suited to the class of students for which the colleges were intended, that the demand and utility for the course is obscured by its being made a road to a degree, that college graduates engaged on the subordinate

staff of the Agricultural Department, with very few exceptions, failed to show any power to develop any original line, that intelligent inquisitiveness and power of independent thought was lacking, that the course engendered too much cram and too little power of application, and so forth. What was the root cause of this failure would appear to be explained in one of the resolutions which stated "that the general standard in the Matriculation or University Entrance Examination does not provide a sufficient basis to enable a student to take full advantage of the higher instruction obtainable in the existing agricultural colleges in India" and the Board recommended that a general higher education is necessary in all students admitted to such a course. In other words, it would appear that the standard of general education in the country was too low to afford suitable material with which to man colleges of such an advanced type as those which had been set up by the Agricultural Department. In fact the colleges as educational centres were ahead of the times—primary and secondary education was too backward. Consequently the Board suggested a compromise by lowering the standard of the college curriculum to meet existing conditions and expressed its approval of a two years' preliminary practical course, which had been prepared for the agricultural college at Coimbatore as an introduction to the more advanced course. Many of the colleges have since adopted this, with the result that admissions have considerably increased. While we may expect that the Department will benefit by an increase of recruits for filling its subordinate posts, it has yet to be seen how far the education of the cultivators will be influenced by the change. My own view is that these colleges as instruments for education will not accomplish very much, for the simple reason that they are ahead of the times and that there can be no real demand on the part of the youth of the country for an advanced agricultural course until considerable progress has been made in primary and secondary education and in the improvement of agricultural methods. Not until the industry is more highly developed and the standard of living has been raised, will there arise a demand for higher education amongst the agricultural classes.

The creation of agricultural colleges, however, is by no means the only effort that has been made to improve the education of our agricultural youth. Agricultural schools under the supervision of the Agricultural Department have been started in some provinces which were commended by the Board. They give considerable promise of success and, in my belief, deserve every encouragement. Also, there have been attempts in all provinces to set up a system of rural education by imparting instruction based upon the agricultural surroundings of the children, and endeavours have been made to use nature study as a means to that end. But so far the results, we must admit, have been of a microscopic character.

But there is a form of education which is not included in those I have mentioned and is unknown in India. It is a form of education which has been adopted in certain parts of America and which has of late attracted a considerable amount of attention. It is in my humble opinion applicable to the conditions existing in India and offers opportunities in which officers of the Agricultural and Educational Departments could profitably combine to make the problem of education of the masses easier and more efficient. I will give a brief description.

In America general education is carried on chiefly by the Government by whom large sums of money are yearly allotted to the cause of education, but privately supported colleges are abundant and both these and Government schools are largely assisted by private benefactions, the most important of which are controlled by a private body known as the General Education Board.

Ten years ago great interest had arisen in the upraising of the Southern States whose industrial and educational conditions had fallen very much behind those of the Northern States. Conditions in the Southern States resemble in many particulars those which obtain in rural India. About 80 per cent. of the population is agricultural, depending for its livelihood almost entirely on the produce of the soil. There was great backwardness in both educational and industrial progress. Unfavourable economic conditions existed which were mainly the result of rural poverty. While the average

annual earnings of agriculturists in the Northern States were more than 1,000 dollars, those in the Southern States were as low as 150 dollars. Under the auspices of the General Education Board an enquiry was set on foot to study the educational conditions in the Southern States and to devise the ways and means for improving them. The very practical way in which the enquiry was conducted is characteristic of the American people. Surveys were planned State by State, Conferences were held, Monographs were prepared, dealing with the various points on the organization of education. The conclusions which resulted from this enquiry are peculiar. To quote from the Report, it "convinced the Board that no fund, however large, could, by direct gifts, contribute a system of public schools; that even if it were possible to develop a system of public schools by private gifts, it would be a positive disservice. . . . . The public school must represent community ideals, community initiative, and community support, even to the point of sacrifice." The Board therefore resolved that assistance should be given not by foisting upon the Southern States a programme of education from outside, but by aiding them and co-operating with them in educating themselves. When, however, it proceeded to apply these principles it was faced with the following initial difficulties. They found the people had not enough money, "that adequate development could not take place until the available resources of the people were greatly enlarged. School systems could not be given to them, and they were not prosperous enough to support them." "Salaries were too low to support a teaching profession.. ....Competent professional training could not exist; satisfactory equipment could not be provided." These conditions were primarily the result of rural poverty. The great bulk of the people was not earning enough to provide good schools and the prime need was money. The Board therefore came to the conclusion that it could render no substantial educational service until the farmers could provide themselves with larger incomes, and consequently they resolved that it was necessary first to improve the agriculture of the Southern States. Now mark what followed. The Board was first advised to address itself to the rising generation

and to support the teaching of agriculture in the common schools. But after thoughtful consideration this plan was rejected. They found that in the absence of trained teachers, the effort was impracticable; moreover, there were no funds with which to pay such teachers, and the instruction itself would not materially contribute to its own support. Finally, it was impossible to force intelligent agricultural instruction upon schools whose patrons were not themselves alive to the deficiencies of their own agricultural methods. Until the public was convinced of the feasibility of superior and more productive methods, the public schools could not be reconstructed; once the public was convinced and by reason thereof better able to stand the increased cost, the schools would naturally and inevitably re-adjust themselves.

"It was therefore deliberately decided to undertake the agricultural education not of the future farmer, but of the present farmer, on the theory that, if he could be substantially helped, he would gladly support better schools in more and more liberal fashion." The Board, therefore, set about an extensive enquiry as to the best means of conveying to the average working farmer of the South, in his manhood, the most efficient known methods of intelligent farming. As a result of this enquiry a movement known as the Co-operative Farm Demonstration was set up. A year was spent in discovering the most effective methods of teaching improved agricultural methods to adult farmers. Dr. Seaman Knapp of the United States Department of Agriculture was engaged to show farmers how to improve their agricultural methods and raise the standard of their industry. It was not long before successful results were obtained. Under improved treatment it may be roughly stated that the crop yields were doubled. Thus in 1909 the average yield in pounds of seed cotton was 503·6 per acre: on demonstration farms the average was 906·1 pounds; in 1910 the figures were 512·1 and 858·9 respectively; in 1911, 624·6 and 1081·8; and in 1912, 579·6 and 1054·8.

In the growing of corn similar results were obtained. In 1909 the ordinary average yield was 16·7 bushels per acre, while on the demonstration farms it was 31·7 bushels per acre. In 1910, 19·3

and 35·3, in 1911, 15·8 and 33·2 and in 1912, 19·6 and 35·4. It is further stated that the poorer the season, the more clearly did the demonstration methods prove their superiority. The work was also studied from the standpoint of the farmer's financial profit. "In Alabama, for example, in 1912, the average yield of lint cotton was 173 pounds per acre; but demonstration acres averaged 428·3 pounds. Demonstration methods, therefore, netted the farmer 255·3 pounds per acre. At the average price of 65 dollars a bale for lint and seed, the farmer made an extra 33 dollars per acre; as there were 8,221 acres under cultivation on the demonstration methods, the total gain was 271,000 dollars. In the same year 7,402 acres were under cultivation in demonstration corn. Demonstration acres averaged 26·9 bushels more per acre than the general average for the State. The demonstration farmers of the State pocketed 139,379·66 in consequence." This was of course in one State alone. These methods have not been restricted to cotton and corn, but have been applied to a very large number of crops and the propaganda is not limited to cultural methods, but is applied equally to the improvement in farm equipment, more comfortable houses, better barns, stronger teams, better implements and cleaner and healthier surroundings. Hence it is claimed that the beneficent results of this work are not limited to financial profit and cannot entirely be measured by money. Characteristic examples of the relief which the new system brought are cited, but one example will suffice. In Mississippi 5 years ago the value of a certain farmer's produce was one dollar per acre and he was 800 dollars in debt. In 1909 his entire farm was worked under the Government method. He averaged 1,100 lb. of cotton against his neighbour's 300 to 400 lb. He made besides 500 bushels of corn and from one special demonstration acre realized 152 barrels of high class seed which he sold for 300 dollars. His debts are now paid and he has cash in the bank. So much for the education of the adult farmer. We now come to the effect this movement has had on the education of youth. We are told that the initiation of demonstration work and the application of the principle of co-operation has resulted in the disappearance of the disorganization characteristic of rural

life. Colleges of agriculture, farmers' institutes, agricultural high schools, "Boys' Corn Clubs," "Girls' Canning and Poultry Clubs" and the like have been brought into existence where practically none of these things existed before, and that the social and educational awakening of the rural South is recognized as being a bye-product of the demonstration movement. Statistics show that the provision for schools has steadily increased. Thus the expenditure for public elementary and secondary schools in North Carolina which was 1,091,226 dollars in 1901, is 4,300,000 in 1913. In South Carolina the expenditure which was 961,897 dollars in 1901 is 2,609,766 in 1913, Arkansas 1,369,809 and 4,279,478, and so forth. These instances give but meagre examples of the important results achieved by the demonstration movement. For greater detail I must refer you to the Report[1] itself.

I think you will agree with me that the educational policy I have described is novel and peculiar. When I say novel, I do not mean that demonstration work has not been used before among farmers and cultivators. We all know that it has, but it is novel in the sense, that never before, so far as I am aware, has demonstration been used in any country as a force and weapon for education so as to make it a condition precedent to the education of youth. It is a new experiment but a new experiment of a remarkable kind. The results indicate that it is no use to try and educate youth if you do not first secure the welfare of the community to which it belongs and that therefore the development of resources should precede education in order of time. What the American General Board of Education says to the farmer in the Southern States is—You are too poor to supply your sons with education; we could assist you, but we do not consider it proper to do so, unless you yourselves contribute. As you cannot do this, we will assist you to increase your earnings so that you will be in a position to provide yourself with schools. When you have done this we will assist you further. We consider that it would be wrong for us to directly educate the rising generation, if you are not able to participate; in fact we believe

[1] *General Education Board, An Account of Its Activities*, 1902—1914. 61, Broadway, New York.

that it would be a positive disservice for us to do so. Your schools should be started by yourselves, they should represent community ideals, community initiative and community support even to the point of sacrifice.

We have seen how the experiment has succeeded. Might we not with advantage apply the same principles to India? Might we not invite the co-operation of the Agricultural Department in a general scheme and policy of education? Is there any likelihood of success without this? Can we hope to give the youth of this country an adequate educational service unless we go to the root of things, like the Americans have done, and enlist and increase the activities of the Agricultural Department in enlarging the resources of the cultivator and thus build our educational system on the increased prosperity of the agricultural classes? These are the questions I desire to offer for consideration. India is in no better position than the Southern States were 10 years ago. Indeed I think we may safely assert it is in a far worse position. The average earnings of individuals in the Southern States at that time were 150 dollars. In India, according to some authorities, under the most optimistic calculations, they are as low as Rs. 30 per head. You must agree this gives little or no scope for self-help. It therefore seems to me plain that under present conditions we cannot expect the country to supply itself with the means for an advanced system of education. Nor can Government be expected to do so, for Government's resources are limited and depend upon taxation and that in turn depends upon the ability of the people to be taxed. All Government can do is merely to touch the fringe of the problem and supply a modicum of education; it cannot afford to do more. Mr. Fremantle very well describes the situation when he says: "We should surely pause to consider whether the time is ripe for the introduction of a system of general primary education into rural areas. It is a question whether we are not beginning at the wrong end and whether primary education can make any real advance before there is a substantial improvement in economic conditions." These are words which the devotees at the shrine of the policy of free education for the masses might with advantage ponder.

The question then is whether we can, in any way, make the principles which have been so successfully applied in America, applicable to India. My belief is that we can. We have practically the same conditions here as obtained in the Southern States 10 years ago. If anything as I have shown they are a good deal worse. But this is no argument against their adoption. Rather the reverse, for the lower the degree of prosperity, the greater is the need for increasing it. Already in the Provinces a great deal has been done by the Agricultural Department in the way of demonstration of the character described and utilized by the American Board of Education. But it does not go far enough. It, however, forms a nucleus on which to expand and might well be used as a beginning. The work is on the right lines. But we require to do more. We want more men, more money, wider organization, but above all, we require the recognition amongst all classes that in this work lies the germ of future progress. This is a point which is not generally recognized, or, if so, it is certainly not acted upon. While the money spent to-day on education is over 10 crores of rupees, that on agricultural development is only 50 lakhs. That shows that we have not yet got to view these two important problems in their right perspective, and do not fully realize the important relation which agriculture bears to education. Many think that the development of agriculture depends on education, and we gave effect to that view when we started our agricultural colleges. But would it not seem that the truth lies in the opposite direction and that in a backward country like India the advance of education is really dependent on the development of agriculture, and that the best form of education you can give to the rural classes under existing circumstances is demonstration in improved agricultural methods? It was found to be so in the Southern States of America and we have no reason to suppose it is otherwise in India. To carry out the idea it is not necessary to bring our present educational policy to an end. I would not propose anything so revolutionary. Government must, as I have already explained, supply a modicum of literary teaching and this must continue, but it would be an immense improvement if the Agricultural Department were called in to co-operate and

demonstration were given a large share in the general scheme of education.

We could not be expected at first to progress with the same degree of rapidity as in America, because we have to do a large amount of research and experiment before we can demonstrate improved methods on a large scale. In America the advanced stage in the agricultural development of the Northern States supplied ready at hand the stock-in-trade required for at once setting in motion the demonstration movement in the backward Southern States. We are not so forward. Still we have achieved enough with our small band of workers to show that the same kind of work can be done out here and that all we require is expansion. Given the means for this (and who will say it would be a bad investment ?) and a recognition of demonstration as an integral part of a general scheme of education, and I feel sure we shall, by such a policy, lay the best and securest foundations for the advancement of education as well as of the prosperity of the people.

THE SAVING OF IRRIGATION WATER IN WHEAT GROWING.

BY

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AND

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ONE of the main directions in which Indian agriculture can be improved is in the proper use of irrigation water. Overwatering is the rule throughout the Continent, particularly on the alluvium of the Indo-Gangetic plain and in many of the deltaic areas of Peninsular India. Among the many evil consequences of over-irrigation is the development of a superficial root-system, with the consequence that many of the irrigated crops are particularly liable to drought and can only be ripened by the use of enormous quantities of water. Even in arid tracts like Baluchistan, where water is exceedingly scarce and land abundant, similar wasteful practices are in vogue and but little real use is made of the present supplies or of the rainfall which, in this region, though small, is particularly well distributed. With the object of drawing attention to these shortcomings, the water-saving experiments described in this paper, have been carried out. The opportunity has been taken of stating very briefly the main principles on which the right use of irrigation water depends.

I. The Agricultural Factors in the Quetta Valley.

The general agricultural conditions in the Quetta valley resemble, to a considerable extent, those of large areas of Central Asia and are markedly different from those of India. The valley is situated at an elevation of about 5,500 feet above the sea and is surrounded by high mountains. There is a gentle slope from the sides to the centre and the main drainage line is westward.

Soil. The soil varies from brown to black in colour and resembles the alluvium of the Indus valley in general appearance and texture. It is a loess deposit, apparently formed by accumulations of wind-blown dust, sometimes mixed with alluvium. With such a geological history and in a climate of great aridity, there have been no opportunities for the accumulation of organic matter. It is not surprising therefore to find that stable manure and green-manuring lead to an immediate improvement in production. Most of the soil of the cultivated areas does not possess a great range in the size of the particles and behaves on wetting very much like the Gangetic alluvium. Flooding destroys the porosity and the surface runs together easily. Under the dry, hot winds which are frequent at Quetta, irrigated land sets on the surface into a cement-like mass, which cracks in all directions and rapidly loses its moisture. There is a great response to aerating agencies such as heavy dressings of stable manure, the growth of a lucerne crop or green-manuring with *shaftal (Trifolium resupinatum).*

Rainfall. The total rainfall is low, about 10·5 inches a year. Most of the precipitation takes place during the winter months, November to March, often in the form of snow. The shallow, cold-weather depressions, which form over Persia and move down into North-West India, often pass over the Quetta valley, and, in doing so, deposit a portion of their moisture. It is to this cause that the winter rainfall in this tract is principally due. The valley is outside the usual area of the Indian monsoon, but it sometimes happens that the storms which cross the continent from the Bay of Bengal, after depositing most of their moisture in Hindustan proper, break up among the valleys of Baluchistan. These increase the humidity of the air and give rise to showers of rain during the

months of July and August, but the total quantity received is very small.

Besides the winter rain, there are three chief sources of water for agricultural purposes—*karezes*, artesian bores and subsoil water. The usual method of irrigation is by means of the *karez*. This is an underground ditch on sloping land, which collects the subterranean water near the hills and discharges it on to the surface. It is really an adit with a slight slope, driven into a fan talus with a much greater slope of 300 to 600 feet per mile. The land below the opening of the *karez* is watered by gravitation. The artesian bores as a rule are only about 100 to 200 feet deep and are of from three to four inches in diameter. The water comes from underground streams so that this method of supplementing the rainfall is largely a matter of chance. The distance to the water-level in the wells varies a great deal. In the Civil Station at Quetta it is often less than 10 feet, but on the higher land outside it varies from 20 to 30 feet. Little use is made of this water at present for irrigation purposes on account of the expense and trouble of lifting it. There is little doubt, however, that in certain localities, this groundwater is made use of by trees.

Temperature. There is a well-marked winter at Quetta and, from November to March, the general temperature is low. The summer months June, July and August are hot and, during this period, the minimum temperature is high. The mean varies from 40° in January to 78° in July. The feature, however, of the climate is the great daily range of temperature and the fact that during the winter there is a good deal of air movement. The diurnal range varies from 21°·8 in January to 32°·7 in November.

Humidity. Except when the south winds blow in July and August or after rain, the humidity of the air is low, much lower than in many parts of the plains of India. The drying effect of the air is further aggravated by much air movement, often from the west. Evaporation is therefore rapid so that in fruit and vegetable growing, devices for checking the effects of dry winds are necessary. Mud walls, wind breaks of growing trees and cover crops, which shade the ground, can be used for this purpose.

II. The Present Methods of Growing Wheat.

The wheat crop of the Quetta valley is produced in two very distinct ways—under irrigation and as a dry crop. In both cases, the land is fallowed at least during the summer months preceding sowing. The feature of the irrigated wheat growing area near Quetta is the large amount of fallow land and the concentration of the available irrigation water on to a comparatively small area. Land is abundant but water is scarce. Where manure can be obtained, as in the region surrounding the Cantonments, it is freely applied for the production of this crop.

Irrigated wheat. During the early part of the year a certain amount of rough cultivation is given to the fields selected for wheat. When Canopus appears in September, the preliminary watering is given and, when the land is dry enough, the seed is broadcasted on the surface, the land cross-ploughed and then levelled with the beam. After 40 days, the first irrigation is applied followed by the second at the end of December. Watering is stopped during the months of January and February and the third irrigation is given at the end of February. There is then a cessation while the crop is shooting and the fourth application takes place about the middle of April followed by at least two more at intervals of about fifteen days till the grain has formed. Including the preliminary irrigation before sowing, at least seven waterings are given for irrigated wheat and, to obtain the highest yield, the land is always heavily manured.

The most interesting and significant features of the crop are the slow rate of development about the time the ears appear and the manner in which ripening takes place. The well-known changes in colour of the ears during ripening do not occur at Quetta. The ears dry up slowly from the tips rather than ripen and the full colour of the chaff is not developed. There appears to be a factor which limits the rapid ripening of the crop and there is some evidence for supposing that this is want of air in the soil caused by the destruction of the tilth by frequent watering.[1] Towards the end of the season, the temperature rises rapidly and the hot, dry, westerly winds set in.

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[1] Soil Ventilation, *Bulletin* 52, *Agricultural Research Institute, Pusa,* 1915.

Dry wheat. For the unirrigated wheat, the fields (*bands*) near Quetta are embanked. These are filled with rain or flood-water in the summer or winter, after which they are ploughed and the seed sown. In other parts of the District, such as Pishin and Toba, the dry wheat tracts are seldom embanked and sowing takes place only when the rain and snowfall have given sufficient moisture for the purpose. Everywhere the dry crop is dependent on good rains in the winter and spring and sowing usually takes place only after the fields have received sufficient moisture. Dry wheat in the Quetta valley is a precarious crop and the yield rarely exceeds five maunds of grain to the acre. In parts of the Quetta tahsil and in the Alizai circle of Pishin, a system, known as *garar*, is followed in dry crop lands, the soil being prepared in September and October and the seed sown without moisture after which it is left till the winter rains cause it to germinate.

Yield. The results of numerous crop cutting experiments in the District are summed up in the Quetta-Pishin *Gazetteer* (p. 102) as follows :—

"In Quetta, 75 expeiiments were made in 1895-6 and the outturn of wheat per acre in irrigated land was found to be 15½ maunds, the highest being 17½ maunds in the Kasi circle and the lowest 14 maunds in the Baleli and Durrani circles. Mr. J. A. Crawford, in commenting on the items, remarked that the results of crop experiments were notoriously apt to be high. Further experiments, made in 1903-4, however, showed still higher returns, the average in irrigated and manured land being 24 maunds 6⅔ seers, and in irrigated land, not manured, 13½ maunds. In other parts the average has been found to be as under :—

	Pishin Mds.	Shorarud Mds.	Chaman Mds.
Land irrigated and manured	25	15	15
Irrigated land not manured	16	12	10
Dry land	5	5	3

The average yield per acre in land under the Government irrigation works in Pishin, which are not generally manured, has been as follows :—

		Mds.	Srs.	Ch.
Shebo Canal, 1892-3 to 1903-4	...	5	32	14
Khushdil Khan, 1892-3 to 1903-4	...	7	34	9

In such a manner is the wheat crop produced in the Quetta valley at the present time. It will be interesting to examine critically these processes in the light of the principles on which agriculture has progressed in other arid tracts and to ascertain how far they conform to the best irrigational practice.

III. The Principles Underlying Water Saving.

In the growth of the wheat crop under conditions where the rainfall is twenty inches or less, experience has shown that, in order to obtain the highest possible yield, the water-conserving methods of dry farming must be employed. Where in such cases the rainfall has to be supplemented by irrigation and the wheat crop has to be grown, partly by means of the natural rainfall and partly by artificial watering, it has been found, both by experience and by experiment, that the best results are obtained by the skilful application of the following five principles:—

1. **The irrigation water available should be spread over the largest possible area.** This rule is based on the fundamental law that, as more water is applied to a field of wheat, there is a regular diminution in the yield per unit of water applied. This will be clear from the recently published Utah results.[1]

TABLE 1.

Yield of wheat with varying quantities of irrigation water.

Inches of irrigation water applied	Bushels of grain to the acre	Pounds of straw to the acre	Pounds of straw for each bushel of grain	Bushels of whea for each inch of water
5·0	37·81	2,986	79	7·56
7·5	41·54	3,301	75	6·39
10·5	43·53	3,452	79	4·35
15·0	45·71	3,954	87	3·05
25·0	46·46	4,311	93	1·86
35·0	48·55	4,755	98	1·39
50·0	49·38	5,332	108	0·99

[1] Widstoe, *Principles of Irrigation Practice*, 1914, p. 250.

The chief point which emerges from these experiments is that when five inches of irrigation water were applied each inch produced 7·56 bushels of wheat. When the water was increased to fifteen inches, each inch yielded only three bushels. When the large quantity of fifty inches was employed, each inch produced less than a single bushel of wheat. Small waterings therefore do far more good per inch of water than large applications. This point is rendered clearer by the results obtained in Utah when 30 inches of water were spread over six acres instead of over one. The total yield of wheat rose rapidly from 47·51 to 226 bushels.

	30 ACRE-INCHES SPREAD OVER				
	1 acre	2 acres	3 acres	4 acres	6 acres
Grain	47·51	91·42	130·59	166·16	226·16 bushels
Straw	4,532	2,908	10,256	13,204	17,916 pounds

These figures clearly indicate that when the quantity of water is limited, as it is in most arid tracts, the least possible amount needed to ripen a wheat crop must be applied to each acre of land. With these facts before us we should expect that the six or seven heavy irrigations applied to a single crop of wheat at Quetta must result in an enormous waste of valuable water.

2. **Heavy waterings reduce the proportion of grain to total crop.** This principle is well known and is confirmed by numberless experiments. With the increase in available water, the length and weight of straw increase far more rapidly than the weight of grain. As straw is much cheaper than wheat, it is clearly of no advantage to use valuable water mainly to increase the yield of straw. This point is brought out in Table 1 above where in the fourth column the rise in the proportion of straw to grain with increasing irrigation is indicated.

3. **The growth period of wheat is increased by heavy watering.** All observers who have carefully studied the wheat crop must have been impressed by this fact. At Quetta, the difference between

the time of ripening of wheat grown with the minimum quantity of water and that raised by the zamindars is at least a month. Late ripening is a great disadvantage in the Quetta valley as towards the end of the season the temperature rises rapidly and this rise is accompanied by hot, dry, westerly winds. Maturation therefore takes place under exceedingly unfavourable conditions as is shown by the fact that the wheat crop does not really ripen and show the usual development of bright chaff colour, but merely dries up to a somewhat uniform dull white. It is not surprising, therefore, that the grain is not well filled and that the feeding value of the *bhusa* is greater than that imported from Sind.

4. **When the water supply is limited, the root development of the wheat crop must be deep.** The first stage in the growth of the wheat plant is largely subterranean and, during this period, root formation goes on rapidly, provided the soil has been well cultivated and contains a sufficient supply of air and moisture. Wheat should not be watered during this stage, as irrigation, by interfering with the air-supply, tends to check the downward development of the roots and to encourage superficial rooting. Such a shallow-rooted crop cannot make the best use of the winter rain and is particularly liable to suffer from drought. The two early waterings of the wheat crop at Quetta are therefore harmful as, after sowing, the roots should be made to grow down deeply into the soil and abstract moisture from the lower levels.

5. **The soil moisture must be preserved as far as possible by a surface mulch of dry soil.** The moisture in the soil, in which a wheat crop is growing, is lost mainly by evaporation from the surface and also by transpiration through the plant. It is obvious that when the water supply is limited, as much water as possible must be passed through the plant and as little as possible lost by evaporation from the surface of the ground. The easiest method of checking this evaporation in the case of wheat is by means of a surface mulch of dry soil, produced and maintained by suitable methods of cultivation. The loose, dry layer of earth on the surface hinders the movement of soil water into the air. The action of the mulch is not difficult to explain. The moisture in the soil occurs as thin

films surrounding the soil particles and, after surface irrigation or rain, these particles run together into a position of close packing so that the water films form a continuous system right through the soil. At the surface they come in contact with the atmosphere. If the air is dry, evaporation of the water takes place at once. When the air is dry and warm and also in rapid motion, as it often is in arid tracts, the evaporation is exceedingly rapid and the irrigated or rain-wet surface rapidly dries. As the water near the surface of the soil passes into the air as vapour, a continuous movement of water takes place from the soil and subsoil to take its place. At the same time deep cracks are formed, so that the evaporation soon begins to affect the moisture in the subsoil as well. The result is rapid drying out to a great depth. The dry mulch breaks the contact between the films of water round the particles and the atmosphere and checks evaporation. Its efficiency depends largely on its depth. A three-inch mulch will often reduce the loss by evaporation at least fifty per cent., while a six-inch mulch is much more effective. A mulch, about a foot thick, often prevents evaporation altogether.

In wheat growing, the surface mulch has to be produced while the crop is in the ground and often while the seedlings are small and tender. Deep mulches are therefore out of the question as their formation would destroy the crop. It is found that very effective mulches can be produced in a young wheat crop by an implement known as the lever harrow. This is an ordinary toothed harrow so constructed that the slope of the tines can be altered by a lever. By sloping them backwards, a lever harrow can be drawn over a young crop of wheat without damage to the plants and, at the same time, any surface crusts can be broken up and a mulch of dry earth produced. On soil like the Indo-Gangetic alluvium or that of the Quetta valley, a single cross-cultivation with these harrows will produce a mulch about two inches thick which goes far to preserve the water in the soil. The harrow can be used till the wheat is nearly a foot high. Whenever rain falls, the surface must be harrowed and the dry mulch re-formed. In the Quetta valley, no such implement as a harrow is used by the

zamindars and they do not understand the value of surface mulches. In consequence, their dry wheat has to grow and ripen with a surface crust always present and with the soil moisture constantly exposed to free evaporation into the dry atmosphere. There is little wonder that the crop is so stunted and that the yields are so poor.

If, therefore, the methods of growing wheat at Quetta are examined in the light of the best modern practice in arid regions only one conclusion can be drawn. The local practices are wasteful and unscientific in the extreme. Water is thrown away in all directions ; there is no effort to conserve the soil moisture and to make the best use of what is, to the wheat crop, a most timely and well-distributed rainfall. All the conditions were therefore exceedingly favourable for the conduct of water-saving experiments and, as soon as the land for the new Experiment Station was acquired, these were set in motion.

IV. Experiments in Water Saving at Quetta.

The experiments in water saving in wheat growing, conducted at Quetta during the last three years, have been of two kinds. Wheat has been grown on the natural moisture only and also on the rainfall, supplemented by a single irrigation applied to the land before sowing in October. The amount of the rainfall during the period covered by these investigations is indicated in the table below which gives the precipitation at the Civil Hospital, situated quite close to one of the experimental plots.

Table II.

Rainfall in inches at Quetta, 1912-1915.

	1912-13	1913-14	1914-15		1912-13	1913-14	1914-15
September	*nil*	*nil*	0·02	April	0·12	0·97	1·96
October	*nil*	0·19	1·87	May	*nil*	0·55	*nil*
November	0·03	0·95	1·91	June	0·08	0·46	*nil*
December	1·50	0·90	1·16	July	0·19	0·76	*nil*
January	0·69	1·70	0·43	August	0·12	*nil*	*nil*
February	3·73	3·29	0·45				
March	2·69	1·20	1·44	Total	9·15	10·97	9·24

It will be seen that practically all the rainfall is received between October and May during a period when the wheat crop can make use of it. It is unusually well distributed and can be entirely absorbed into the ground, provided the surface is kept in the proper condition to receive it. This distribution of the rainfall is an ideal one from the point of view of the wheat crop, and it is a great pity that so little use is made by the cultivators of the gifts of Providence and that they do not attempt to conserve the moisture by means of a surface mulch of dry soil.

Wheat grown on natural moisture only.

In the season 1913-1914, two large plots were sown with wheat on natural moisture only. In both cases, no storm water was embanked on the land before or after sowing as this was impossible on account of the situation of the ground. The only moisture at sowing time was that conserved during the dry, hot summer from the previous winter rains by a surface mulch of dry soil, some three to four inches in depth.

The first plot, three acres in area, was situated at the new Experiment Station about two and a half miles from Quetta. The land was high-lying and freely exposed to the hot, drying winds. It was unmanured and so situated on a ridge that it received its own rainfall only and was not subjected to any surface wash from higher land. The mulch was found to conserve the soil moisture exceedingly well up to the end of June but, during the hot months of July, August, and September, the subsoil dried a great deal and, at sowing time, there was insufficient moisture for even germination and for maintaining the seedlings till the winter rains set in. The result was a very thin crop which gave only 2 maunds 27 seers of grain and 7 maunds 23 seers of *bhusa* per acre.

The second plot was just over half an acre in area and was situated on low-lying land within the Civil Station at Quetta and to the south of the Residency. The land was heavy in texture, the subsoil moisture was somewhat near the surface and the plot was protected from the dry winds by trees and high walls.

The growth was luxuriant but some damage was done by yellow rust (*Puccinia glumarum*) as the wheat came into ear. The yield worked out at 21 maunds 1 seer of wheat and 40 maunds 38 seers of *bhusa* per acre. The conditions were, however, exceptional and there is no considerable area of land in the valley where similar crops can be obtained. In one respect, however, the result is of interest. The land was typical of most of the area on which the Civil Station has been built, and the fact that a yield of over 20 maunds of wheat to the acre was obtained without irrigation at all shows that a great deal more use could be made of the subsoil water than is at present the case. It can readily be understood how easy it is to over-irrigate the land in this tract and to turn the foliage of the peach trees yellow.

The water conservation methods employed in these experiments were the same. In both cases, the crusts formed by rain were broken up by the lever harrow and a mulch of dry soil, about an inch and a half in depth, was left on the surface. After the wheat began to shoot in March, the use of the harrow had to be discontinued with the result that the crop had to ripen with a distinct surface crust formed by the late rains in March, April and May. This led to a considerable loss of valuable moisture during the ripening period.

Wheat grown with a single irrigation.

Two large scale experiments were made at the Experiment Station in 1912-13 and in 1914-15, in which a single irrigation was applied to the land in September prior to sowing in October. When it was observed in 1912 that, in ordinary exposed wheat land, a mulch of dry soil three to four inches in depth was insufficient to conserve the subsoil moisture from one winter to sowing time the following October, it seemed probable that a single irrigation, applied before sowing, might prove effective. This would enable a thorough cultivation of the land to be carried out before putting in the seed and would reinforce the water in the soil and subsoil to such an extent that there would be ample moisture for germination and for rapid root-development before the winter rains were received.

The land was irrigated by surface flooding in the ordinary way and, as soon as the surface was dry enough, it was cultivated by means of the spring-tooth cultivator and immediately levelled with the beam. This operation is of the greatest importance in crop growing in Baluchistan both from the point of view of the saving of water and of the production of a good tilth. Irrigated land dries very quickly, and, unless it is ploughed up at exactly the right moment, large clods are formed which cannot be broken down by the beam. Where the area watered is several acres and the cattle power is limited, it is impossible to deal with all the land at the proper moment with such a slow-working implement as the country plough. The consequence is a great loss of moisture and a poor tilth. What is required is a machine which will rapidly cultivate the surface of a large area and, by the production of a surface mulch, check the rate of evaporation and also help to make a good tilth. This can be done easily and rapidly by the spring-tine cultivator followed by the beam. A pair of cattle with one of these machines will cover at least three acres in a day and, by checking evaporation, enable the land to be ploughed and sown with ease, at the same time producing natural conditions in the soil which lead to the formation of an excellent tilth when the land is ploughed.

After sowing, which was done behind the plough in the ordinary way, the only treatment necessary was the breaking up of surface crusts after rain and snow. This was done by drawing over the crop, by means of two bullocks, a pair of Canadian lever harrows. By sloping the tines backwards these harrows will pass over young wheat without damage and, at the same time, break up thoroughly the crusts formed by rain. The cost of a pair of these harrows, f. o. b., at New York, is 12·90 American dollars (Rs. 40-4-0) and they cover a strip of land 9 feet 8 inches wide. The number of harrowings required naturally varies with the year. For the 1915 crop, the young wheat was harrowed four times. After the crop began to shoot, the use of these harrows had to be discontinued and the crusts formed by the rains of late March and April led to a great deal of loss of moisture. Experiments are in progress to find means of harrowing the wheat up to the time it comes into ear.

The 1915 crop ripened about a month before that of the cultivators and was affected by yellow rust far less than the irrigated wheat. An interesting feature was the full development of the chaff colour which is hardly ever seen in the country crop. The results of the experiments are given in Table III.

TABLE III.

Yield of wheat at Quetta with a single irrigation.

Season	Area in acres	Yield of grain per acre	
		M.	S.
1912-13	3·00	18	30
1914-15	2·85	16	28
	Average	17	29

One maund = 82·27 lb.

The average yield of these large scale experiments was thus 17¾ maunds per acre or four and a quarter maunds above the average yielded by similar unmanured land with six or seven irrigations (p. 18). The real difference between the Experiment Station results and those obtained by the people can best be realized however by comparing the produce in both cases from the same amount of water. The zamindars water one acre seven times and obtain an average of 13½ maunds of grain. The same amount of water spread over seven acres, if used according to the method employed at the Experiment Station, would give 7 times 17¾ or 124¼ maunds of wheat. The difference in favour of the experiments is therefore 110¾ maunds of wheat. If the average irrigated acreage of wheat in the Quetta valley is multiplied by 100, the result would indicate, in maunds of wheat per annum, the present annual waste of water on this crop alone. On every 100 acres of irrigated wheat, the water now lost would produce 10,000 maunds of grain and a large amount of straw of a total value not far short of half a lakh

of rupees. All the water now lost could not of course be translated into grain and *bhusa* as the necessary preliminary irrigations could not be done in time with the water supply now available. A large proportion of the loss however could be utilized in wheat growing, while the remainder could be employed for the winter watering of fruit trees and in the production of fodder crops like *shaftal* and lucerne.

It is clear that as far as irrigated wheat growing is concerned, there is an enormous loss of water which might be profitably employed. The skilful use of the lever harrow after rain would also increase the yield of the unirrigated or dry crop wheat. Examined scientifically, the methods now in vogue are wasteful in the extreme, both as regards the precious irrigation water and the winter rain and snow which cost nothing. To enable the zamindar to improve his practice, two new implements are necessary—the spring-tine cultivator[1] costing about thirty rupees and a pair of Canadian lever harrows which cost at New York before the war about forty rupees. With proper care and if the working parts are replaced when worn out, these implements would last ten years at least, so that the annual cost would not be over fifteen rupees. Each cultivator need not purchase these implements for his own use. Two spring-tine cultivators and a pair of lever harrows would suffice for an ordinary village. The cost of using them is, from a zamindar's point of view, negligible as he now has to keep cattle as well as servants to feed and look after these animals. A little gentle exercise for the men and animals in the winter in harrowing the young wheat after rain would do them no great harm. The economics of the suggested improvements in production do not therefore admit of argument. At a small cost, a very material increase in wheat production is possible in the Quetta valley. The increased yields of grain and *bhusa* will directly benefit both the people and Government while the greater production of the neighbourhood is an obvious military advantage.

[1] The spring-tine cultivator can be used for many other purposes besides wheat growing, such as cultivating between the rows of trees in fruit gardens, breaking the surface of lucerne fields and sowing crops like maize and *juar*.

One possible objection must be dealt with at this point. It may be urged that results such as those above are only possible under European supervision and that the zamindars could not possibly repeat them. The reply is that the Experiment Station results were obtained by the Indian staff and that all the operations, including sowing, were carried out by the overseer from written directions during our absence from Quetta.

Besides their bearing on the local agriculture, these experiments have some application to Indian conditions where the saving of irrigation water has not, up to the present, received very much attention. There are several tracts in India where a fair wheat crop might easily be raised on a single irrigation applied prior to sowing. In Bundelkhand and other black soil tracts, where the monsoon often ceases early and where there is insufficient moisture in the ground for germination, a preliminary irrigation before sowing would cool [1] the land and also enable a rapidly maturing variety like Pusa 4 to ripen a full crop of wheat. Irrigation after sowing, on heavy black soils, is likely to interfere with the air supply of the crop and to diminish the yield so that some of the various tank projects in the Central Provinces might be designed to irrigate a large area in September and early October once rather than a smaller number of acres several times during the cold weather. Experience will soon prove which of these methods is the one to adopt. In such comparisons, the yield per acre-inch of water must be considered, not the yield per acre.

In some of the alluvial tracts like Oudh and the middle Doab, a single irrigation in early October (provided the moisture is properly conserved) will probably be found to be sufficient for a rapidly maturing wheat variety. After flooding the surface, the land would

[1] It is well known that the late rains of September and early October are very beneficial for *rabi* crops. There is considerable evidence for supposing that a large portion of the benefit is due to the cooling effect of this rainfall on the soil. This enables the cold-weather crops to form a deep and vigorous root-system. In years when the rains cease early and the soil is hot at sowing time, it is more than likely that a single irrigation in late September or in early October, besides giving abundant moisture for sowing, would also cool the ground very considerably. The matter is one worthy of extended experiment as it is probable that in this way more use could be made, in several tracts of India, of the water available.

have to be cultivated as soon as possible with the spring-tine cultivator, followed by the beam so as to check evaporation and to allow of the natural formation of a perfect tilth before ploughing and sowing. After sowing, the lever harrow would have to be used as long as possible so as to conserve the soil moisture and to break up the crusts formed by rain and dew.

Besides the saving of irrigation water, such a method of wheat growing in India has other advantages. Both the sowing and harvesting periods could be extended. A rapidly growing variety can be sown quite late, while the same variety, sown at the usual time, would ripen considerably earlier than the ordinary crop, thus allowing of an early harvest and so relieving the strain on the cattle and labour available at this period.

INDIAN HEMP FIBRE.

(*Crotalaria juncea.*)

BY

C. D'LIMA.

Of the many Indian products the trade in which has been making steady strides during the last ten years, Hemp, the fibre of *Crotalaria juncea*, is by no means an unimportant one. Roxburgh and the other authors who have followed him have left behind them most valuable literature bearing on the subject, while the officials of the Agricultural Department have by means of Ledgers and other publications issued from time to time added considerably to the richness of the literature already extant. In this article the writer does not claim to make any material addition to the said literature, but aims merely at placing before the Indian Authorities and the European trade certain aspects of the subject from a practical business man's standpoint, and offers a few suggestions which the writer thinks might prove of interest to the trade generally, and which, if carried out, might redound to the advantage of the Indian agriculturists to a very appreciable extent.

To be able to gauge correctly the importance of the export trade in Hemp, one has only to refer to the Trade and Navigation Returns of the Presidency of Bombay, and the appended Statement ought to serve to give one a fair idea not only of the quantity exported from year to year and of the money value such exports represent, but also of the manner in which the trade is distributed among the various foreign markets. It is true that since 1908-1909 there has been a falling off in the quantities exported due more to bad crops in some of the more important hemp-growing districts than any other cause, but, as will be seen from the Statement appended

hereto, the decrease in the quantity is compensated for by an increase in prices.

The enormous quantities shown in the Statement do not, however, represent the produce of the Bombay Presidency alone; on the contrary except for a few thousand bales the bulk of these exports is made up of fibre obtained from the Central and United Provinces where it is grown on a considerably larger scale than in the Bombay Presidency, and where the quality of the fibre produced is uniformly superior to that available in the Bombay Presidency, excepting of course the Ratnagiri district which produces a superior and therefore valuable fibre. Whether or not it is possible to extend the cultivation of hemp in the Bombay Presidency and expand the trade in it on a parity with the trade now being done in some of the more important hemp-growing districts in the Central and United Provinces is a question which will be dealt with below.

For any Indian fibre to be able to command a ready sale in the European markets and realize good prices, it is essential that it should be of good length, thin and soft, strong, and above all free from sand and dust; indeed the Factory Regulations in Europe, and in England particularly, are so very strict, where the utilization of dirty fibres is concerned, that European buyers have already taken to steadily rejecting all fibres which contain a large admixture of sand and mud, and it is not unlikely that what little trade there is at present in inferior fibres will disappear altogether before long.

In the light of these observations we shall proceed to discuss the prospects, if any, of fibre prepared in the Bombay Presidency being able to compete successfully with fibre prepared in the Central and United Provinces, for unless it can be established that such competition is possible even to a remote degree, the industry is certainly not worth persisting in, and the agriculturists might as well turn their attention to the raising of some other crop which is likely to prove more lucrative than hemp.

From figures kindly supplied to the writer by the Director of Agriculture, Bombay, in 1907, it appears that the area then sown with hemp was not less than 22,116 acres. Since then the acreage

Quantities and value of Hemp exported from the Presidency of Bombay in each official year from 1904 to 1914.

	1904-1905.		1905-1906.		1906-1907.		1907-1908.		1908-1909.		1909-1910.		1910-1911.		1911-1912.		1912-1913.		1913-1914.	
	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.	Quantity Cwt.	Value Rs.
British Empire.																				
United Kingdom	80,906	8,53,935	96,222	10,07,007	80,105	9,32,643	96,465	12,01,148	79,673	10,94,226	90,957	12,04,171	82,973	11,10,866	34,632	13,19,305	109,156	20,32,053	89,472	15,93,452
Victoria	60	720	83	1,328	...	......	...	......	...	......	...	......	...	......	...	......	...	......	...	......
Bahrein Islands	...	......	...	......	...	......	...	......	...	......	57	914	86	1,173	93	1,106	21	266	48	742
Other Countries	42	504	5	86	65	920	69	851	45	564	17	280	26	278	7	120	10	160	2	20
Foreign Countries.																				
Sweden	...	......	...	......	...	......	...	......	350	4,900	350	6,125	...	......	180	1,800	555	7,095	310	3,100
Norway	...	......	...	......	283	4,252	18	180	...	......	21	420	350	4,900	14	224	...	......	965	10,525
Denmark	...	......	...	......	7	70	175	1,750	...	......	175	1,750	...	......	540	5,400	509	5,090	1,140	11,400
Germany	25,619	2,40,587	31,675	3,34,753	38,019	4,12,640	75,161	10,07,382	39,069	5,53,169	41,137	5,97,174	38,711	4,81,902	34,891	4,79,955	47,779	7,54,604	39,401	6,12,894
Holland	875	7,500	175	1,500	437	6,569	101	1,790	...	......	17	245	88	880	339	5,260	729	14,385	...	......
Belgium	133,727	13,06,855	120,671	12,01,948	117,779	12,99,909	137,127	16,44,334	104,311	14,18,047	67,724	8,43,374	68,916	8,49,127	57,634	7,61,635	78,229	12,16,330	72,694	11,08,890
France	8,809	1,03,696	11,821	1,25,725	12,278	1,33,228	19,967	2,30,732	14,448	1,66,715	18,501	2,19,198	8,896	1,09,235	7,516	1,18,036	11,969	2,06,910	9,893	1,34,121
Spain	375	7,125	685	8,335	557	6,450	1,197	13,562	4,153	46,401	2,824	29,900	1,484	16,680	1,051	11,347	1,070	12,625	2,779	39,500
Italy	5,224	58,689	1,880	18,772	2,995	38,411	8,014	1,11,841	4,189	55,548	3,836	45,807	2,520	35,825	2,405	33,586	2,045	32,262	6,122	1,02,287
Austro-Hungary	...	......	70	840	...	......	458	8,226	311	5,093	...	......	473	7,010	158	3,420	180	2,707	318	5,555
Asiatic Turkey	...	......	...	......	...	......	...	......	...	......	29	410	381	4,359	294	4,398	326	6,470	75	1,285
Muscat Territory and Oman ...	3,258	43,143	2,762	33,567	2,151	31,546	2,070	36,351	1,974	30,630	1,835	27,357	2,397	36,797	2,077	35,044	1,493	26,832	1,095	20,019
Other Native States in Arabia ..	...	......	3	36	...	......	141	2,820	...	......	95	1,417	480	8,214	373	6,324	194	3,443	62	1,081
Persia	580	7,074	64	822	93	1,128	269	4,745	778	10,317	107	1,517	532	8,340	260	3,402	237	4,158	373	5,330
Japan	1,091	13,082	914	11,574	519	5,518	...	......	...	......	1,225	14,000	...	......	...	......	...	......	...	......
Italian East Africa	...	......	...	......	...	......	...	......	77	1,365	103	1,396	169	2,519	76	1,403	37	592	38	708
Somaliland	...	......	...	......	87	1,215	63	1,268	...	......	...	......	...	......	...	......	...	......	...	......
Other East African Ports ..	177	1,771	25	365	...	......	...	......	...	......	...	......	...	......	...	......	...	......	...	......
U. S. of America	...	......	...	......	...	......	...	......	...	......	...	......	350	5,250	...	......	...	......	...	......
U. S. of America (Atlantic Coast)	...	......	...	......	...	......	...	......	...	......	...	......	...	......	220	3,307	350	5,250	...	......
Other Countries	41	497	37	572	...	......	...	......	9	99	...	......	...	......	1	20	...	......	3	36
TOTAL	260,784	26,54,178	267,092	27,52,230	255,375	28,74,499	341,495	42,66,980	219,387	33,87,077	229,060	29,95,485	208,852	26,83,745	192,771	27,95,092	254,892	43,31,232	224,790	36,50,945
	...	£176,945	...	£183,482	...	£191,635	...	£284,465	...	£225,804	...	£199,699	...	£178,916	...	£186,339	...	£288,749	...	£243,329

utilized for hemp cultivation in the various districts has probably undergone a considerable shrinkage, as the quantity of fibre exported is nothing like what it should have been if such a large area as 22,000 acres were under cultivation.

The principal hemp-growing district in the Bombay Presidency at present is the Ratnagiri district, and the fibre produced there which to the trade is familiarly known as "Deoguddy Hemp" always commands a ready sale and invariably realizes a higher price than that obtained for the best descriptions of fibre produced in the Central and United Provinces. Except when owing to long drought the plants are stunted affording fibre so very short as to render it sometimes almost unmerchantable, or when owing to incessant heavy rains during the maturing season and again during the retting season the fibre undergoes a certain amount of deterioration both in colour and strength, "Deoguddy Hemp" possesses all the qualities requisite in a good fibre. It is of fair length, soft, strong and perfectly clean with a fine gloss, and is in request not only in the English markets but it is also eagerly sought for by Continental buyers. So far therefore as this hemp is concerned, agriculturists would be well advised in extending the cultivation, as compared with the prices realized for other Indian fibres those obtained for Deoguddy Hemp are certainly very remunerative.

There are two other grades of hemp produced in the Bombay Presidency which once commanded a fair sale in the European markets but which of recent years have been steadily falling into disfavour, *viz.*, "Salsi" and "Godhra" hemp. "Salsi" as the name implies is hemp grown in the Island of Salsette, and in his valuable treatise on *Crotalaria juncea* Dr. Watt repeatedly refers to the superior quality of this hemp conveying the impression that not very many years ago the Island of Salsette produced a fibre reckoned superior to even the Bengal sunn-hemp. It seems indeed a pity that the cultivation of hemp should have now been altogether discarded in this part of the Presidency, for if it were possible to prepare in Salsette a fibre possessing the merits which have been ascribed to it by certain authors, it should certainly pay the agriculturists to devote greater attention to this industry, the more so

as there is plenty of waste land available which could not be utilized for raising any other crop except hemp. Might it not be, however, that the hemp referred to by Dr. Watt and others as the produce of Salsette was really Deoguddy Hemp, and that the error has arisen in consequence of Ratnagiri having been taken as a portion of the Island of Salsette !

"Salsi" hemp, as it is known to the trade now and has been so for some years, is the hemp produced in the Belgaum district. It is a very rough fibre and invariably dirty, and it is not to be wondered at that it is being rejected by the European trade. These defects in the fibre are accounted for by two causes : firstly, no care appears to be taken so to sow the seeds as to ensure that the plants should grow thick, with the result that they become bushy and coarse and give inferior fibre ; secondly, quite a large portion of the fibre bears marked traces of the stems having been buried in damp mud for the purpose of retting, and not only does it contain a large amount of mud attached to it but the fibre is very often found to have undergone a process of decomposition before being peeled off and dried. The defects pointed out are not irremediable, all that is needed being a proper method of cultivation and preparation. Unless, however, the agriculturists in the Belgaum district are prepared to place on the market a better and by all means a cleaner fibre, the further cultivation of hemp cannot but be productive of most disastrous results.

"Godhra" hemp which is the produce of the Panch Mahals district is a somewhat superior fibre to "Salsi," but very often equally dirty, in that it contains a large admixture of sand. In years gone by when the Factory Legislation in Europe was less stringent than it is at present "Godhra" hemp was never seriously objected to, but with a more rigorous enforcement of the Regulations factory owners are naturally averse to using any fibre which by reason of its containing a large admixture of sand or mud not only entails heavy expense in getting it cleaned in Europe but might also subject them to heavy penalties. As a "combing" fibre, Godhra hemp might still find buyers, but the demand for hemp for combing purposes is so very limited that it would never pay the agriculturists

to utilize 5,000 to 6,000 acres for raising a crop solely with a view to catering for the requirements of one or two individuals who comb hemp, and that too on a very limited scale. If the nature of the admixture in Godhra hemp was such as to permit the fibre being easily cleaned in Bombay, the difficulty in creating a market for the fibre in Europe would not be great although the agriculturists would be paid relatively lower prices, but as the fibre is made up into plaits when the sand is moist it is almost impossible to clean it as it should be to render it acceptable to the European trade, and in the condition in which the hemp is now sold in the market it is bound to share the same fate as Salsi hemp.

Prantij, Surat and Khandesh hemp is a decided improvement on "Salsi" and "Godhra," but even this is not altogether faultless. The fibre is long and possesses a good lustre, but while in some cases it contains an admixture of sand, in others the fibre contains a large amount of ligneous filaments which detracts from its value. With a little more care, however, in the preparation of the fibre, the hemp from these districts should in course of time be able to replace some of the fibres produced in the Central and United Provinces enabling the agriculturists to earn sufficiently remunerative prices to make it well worth their while to have recourse to the cultivation of hemp on a larger scale.

Hemp grown in other parts of the Presidency seldom finds its way to Bombay either for sale locally or for export, and it is therefore not possible to express an opinion on its merits or otherwise, but if there is any hemp which fulfils the conditions requisite in a good merchantable fibre it should find a ready market and realize a fair price.

Bombay being an entrepôt for the export of hemp other than that grown in the Bombay Presidency, and all the hemp so exported being known to the European trade as "Bombay Hemp," it is proposed to deal briefly with some of the fibres not grown in the Presidency which find their way to European markets through Bombay, and others which might be diverted to this port and exported from here quite as advantageously to the producer up-country

and the European buyer alike as they could be exported from other Indian ports.

Of the two provinces referred to above the United Provinces undoubtedly have a larger area under hemp cultivation than the Central Provinces, but save for 12,000 to 15,000 bales which reach Bombay from the Pilibhit, Bareilly, and Moradabad districts, the bulk of the hemp from the United Provinces is railed to Calcutta and thence shipped to Europe. *Apropos* of the hemp produced in these Provinces, it has been a moot point whether hemp (*Crotalaria juncea*) grown in India is of only one kind or whether there are several distinct varieties of it, or whether the difference in the fibres is due merely to the influence of soil and climate, and the different methods adopted in the preparation of the fibres. Royle seems to have been of the opinion that there were more than one fibre-yielding species of *Crotalaria*, while Roxburgh and others were inclined to the idea that only one species of Sunn-Hemp was cultivated in India. In the *Memoirs of the Department of Agriculture in India, Botanical Series*, Vol. III, No. 3, Mr. and Mrs. Howard of Pusa provide a valuable contribution on the subject, and in the light of experiments personally conducted by them they establish the existence of two cultivated varieties of Sunn-Hemp in India.

This digression has been rendered necessary because of the fact that the United Provinces produce two fibres characteristically distinct, the one resembling the Jubbulpore hemp, the other a white "towy" kind popularly known to the trade as "Sunn," and there is at least one place in the Fatehpur district where seeds sown at the same time and the plants treated in all respects alike give two distinct varieties of fibre, a result which can only be ascribed to the plants being two distinct forms of *Crotalaria*. As the European trade treats these two forms of fibre on a different level, it is perhaps as well to discuss their merits and demerits separately. "Pilibhit Hemp"—this is how the hemp from the United Provinces is known as shipped at present from Bombay to European ports. In many cases of course the description is merely a misnomer, as the fibre supplied under this denomination

does not always comprise the production of the Pilibhit District only. "Pilibhit" hemp is reckoned by the European trade among the cheaper grades of Indian fibres, which from the point of view of the agriculturists in this District is most unfortunate, in that it prevents their obtaining the real value of the fibre. The area under hemp cultivation in the Pilibhit district is over 6,000 acres. Of recent years there has been a marked improvement in the preparation of the fibre, and if care is taken by the agriculturists to maintain this improvement scrupulously avoiding all admixture of dirt, it should be possible to place on the market a fibre by no means inferior to some of the higher priced descriptions of hemp from the Central Provinces. Unfortunately there is a marked tendency, if not on the part of some of the agriculturists themselves, at any rate on the part of those who handle the hemp after it has left the agriculturists' hands, to "fake" it with a liberal admixture of the more inferior hemp from Bareilly and Moradabad districts, with the inevitable result that European buyers not knowing the real quality and worth of the hemp actually produced in the Pilibhit district will only pay a low price for it. To enable one to judge approximately to what extent the "faking" process might be resorted to, suffice it to say that Bareilly district grows as much hemp as Pilibhit and as the two districts closely adjoin each other, the transporting of hemp from the former district to the latter is a very easy matter. So long therefore as the unscrupulous methods referred to are indulged in, the agriculturists of Pilibhit must be content to earn considerably lower prices than they might have obtained if the genuine Pilibhit hemp had been placed on the European markets.

There can be hardly any comparison between Bareilly and Moradabad hemp with Pilibhit hemp. The former is shorter in length, rougher, and above all very much dirtier, and were it sold on its own merits instead of it being used for the purpose above referred to, it would realize very poor prices. That even in the case of this hemp the quality could be improved there is no doubt, but there is no incentive to any attempt being made in this direction, and there never will be, so long as the agriculturists from

these districts can be sure of getting the same price for their inferior fibre as is realized for the superior one from Pilibhit.

And this brings us to the other variety of hemp produced in the United Provinces which has hitherto not been shipped through Bombay but which could be shipped as advantageously through this port as through Calcutta, specially the hemp produced in the Fatehpur, Banda, Allahabad, Jaunpur, Oudh, and Partabgarh districts. These districts chiefly produce what is known to the European trade as "Sunn" Hemp and which is shipped as "Benares" and "Allahabad," the former representing the better and the latter the inferior grades.

Although this class of hemp does not as a rule contain much admixture of mud or sand it is nevertheless very cumbrous to handle as it contains a large proportion of pieces of stems entangled in the fibre. This defect is accounted for by the fact that the retted stems after being partially washed are taken out of the water and exposed to the sun to dry for some hours and are then *beaten* to separate the fibre. This method not only results in the fibres getting entangled but there is always a large proportion of pieces of stems adhering to the fibre, and the process of partially heckling the hemp which the exporter has to resort to to free the fibre of the admixture not only results in a very serious shrinkage in weight but also entails very heavy expense. It is strange that this method of preparing the fibre should be resorted to in some of the districts while in others the peeling process is most in vogue. By the latter process it would be possible to obtain a more lengthy and cleaner and therefore a more valuable fibre than the one available at present.

Sunn-Hemp (*Crotalaria juncea*) is grown in most of the districts of the Central Provinces but chiefly in the Jubbulpore, Mandla, Seoni and Betul districts, and the fibre from these parts as supplied to the European trade is known as "Jubbulpore," "Seoni," and "Itarsi" respectively. Genuine Itarsi hemp is the produce of the Betul district. It is the best quality of fibre produced in the Central Provinces and commands the highest price. The season's turnover as well as the quality of the fibre is, however, very often

affected by unseasonable weather conditions in which case it is replaced by hemp from the Chhindwara or Seoni districts. The only fibre which approaches nearest to genuine Itarsi is that produced in Chhindwara, but as the sales of what is known as "Itarsi" grade invariably exceed the supply, other descriptions are very often tendered under this name. Hemp produced in Seoni itself while slightly inferior to Betul and Chhindwara hemp is superior to that produced in other *tahsils* of the same district such as Bhoma, Gunsoor, Palari, and Keolaree, although all these fibres are tendered by the Indian seller and accepted by the European buyer as "Seoni." Mandla hemp is not unlike Jubbulpore in quality, while as regards the Jubbulpore district, Sihora and Silondi produce a superior fibre to that prepared in Jubbulpore and the suburbs. The Narsingpur district (Kareli and Gadarwara) produces the lowest quality of hemp in the Central Provinces and this is often used for the same purpose in Jubbulpore as Bareilly and Moradabad hemp is in Pilibhit. "Itarsi," "Seoni," and "Jubbulpore" hemp is always in demand both in England and the Continent of Europe, and unless the quality of the fibre should show a marked deterioration these grades would realize uniformly high prices.

Besides the various grades of hemp enumerated above, the only other fibre which reaches the Bombay market is that from the Gulburga district in the Nizam's Dominions. It is well prepared and in normal seasons the quality of the fibre is very satisfactory.

Bombay receives no hemp from the Punjab or the Gwalior State, while the whole of the hemp produced in the Madras Presidency is shipped direct to Europe from the Madras coast ports.

In the Philippines, the Government has thought it fit to introduce legislation standardizing the grading of hemp produced in the country. In India it would be impossible to enforce any such legislation, nor could the Government undertake it seeing that in the case of more important products such as cotton, etc., there is no state control over the standardization of the quality. When, however, one considers the numerous complaints which have reached India from time to time regarding the poor classification

of Indian hemp, and also bears in mind the fact that the prices hitherto realized by the agriculturists in some of the hemp-growing districts have not been quite as remunerative as they might have been, the question which naturally forces itself upon one is whether even without any direct state control it might not be possible to devise ways and means, whereby the European buyer could ensure his obtaining a better and more uniform grading of hemp and the Indian agriculturist a more remunerative price than that he has been getting so far. For the purpose of putting the Indian agriculturist in a position to place on the European market a more valuable article it would be necessary, firstly, to impress upon him the importance of improving his present method for the preparation of the fibre and to try to bring home to him the advantages which are bound to accrue if such improved methods are adopted; and, secondly, to adopt such measures as will put a stop once and for all to the transporting of hemp from one producing district to another. The result of these measures should be that on the one hand the agriculturists will be able to place on the market the genuine article of the district, while on the other the cessation of the inter-district traffic will prevent any unscrupulous admixture detracting from the real value of the superior fibre. The fibre produced in each district would have to be sold and bought on its own merits; if the fibre were of a good quality it would be bound to realize a relatively higher price, and the higher the price the bigger would be the agriculturist's profit. And here arises a very important question. Supposing the agriculturists do succeed in turning out a superior fibre, and supposing also that it is possible to successfully put a stop to the transporting of hemp from one district to another, would that be a sufficient guarantee that the European trade will get the genuine article, and that after it has reached the port of shipment it will not be so manipulated as to render the efforts of the agriculturists and the authorities alike nugatory. The only way, therefore, and perhaps the most successful way of obviating this risk would be for the hemp growers of each district to adopt a co-operative system of handling their produce on lines similar to those prevailing in Norway, Sweden, Australia and other

countries in connection with dairy and other agricultural products. By this method the product of a district would be collected and entrusted to some individual or firm conversant with the intricacies of the trade whose duty it would be to grade the hemp and dispose of it to European buyers to the best possible advantage of the agriculturists. So far as the hemp industry is concerned it should be easy enough to work it on the co-operative system, and the benefits which would accrue therefrom to the agriculturists would undoubtedly be very great.

In the literature bearing on the earlier stages of the Indian hemp industry, instances are freely quoted of the fibre having been valued at prices compared with which the prices now paid by the European trade are very poor indeed. This is due not to any lack of the sense of appreciation on the part of the European buyer, but to the fact of the fibre being very often manipulated to such an extent as to render it almost impossible for the European trade to secure any really superior quality of fibre, and as in the case of all other produce so also in the case of hemp the question resolves itself into one of value for quality. If therefore the Indian agriculturists could be got to produce and turn out better qualities of fibre the European buyer would no doubt gladly respond by paying higher values. The hemp industry is one with a great future before it, and one which deserves to be fostered and expanded.

THE INDIAN SUGAR INDUSTRY.

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I. Introduction.

This article is written with a view to giving a concise statement of the progress up to date of the work in India on sugar and the machinery connected with it so as to enable the ordinary reader to take in a short time a general view of the progress in every branch of the industry and to see the particular points on which attention is to be concentrated in the future, without the trouble and labour entailed in wading through the voluminous literature on the subject a great part of which is either out of the reach of the ordinary reader or so technical as to baffle his search for a precis of facts. To any one desirous of obtaining further information on this subject, the writer would recommend to consult the publications of the Imperial Department of Agriculture in India and the other works too numerous to mention on the subject by different authors in India.

The steady increase which the importation figures for cheap white sugar in this country show is a matter for grave consideration, and the question of how best to strengthen the position of the Indian Sugar Industry so as to enable it to compete successfully with its principal rivals, Java and Mauritius, has been actively engaging the attention of Government during the last five years.

India is the largest producer of sugar (crude cane sugar, mostly in the form of *gur*) in the world. The annual production in round numbers amounts to 3 million tons, cane sugar and *gur* about 2,600,000 tons, palm sugar close on half a million tons. But the

annual consumption is over $3\frac{3}{4}$ million tons which leaves a deficit of over $\frac{3}{4}$ million tons which is met by importation of white sugar from Java and other sugar-producing countries. Our imports of this commodity amounted in 1913-14 to over 800,000 tons.

While it is true that some part of these imported foreign sugars is utilized for mixing with *gur* to give it the appearance of country-made sugar so as to command the higher price which some people are willing to pay, and the sweetmeat makers take an increasing quantity of white sugar as the pure white colour suits their trade, yet there is no doubt that in consequence of the changes in taste resulting from the educational and economic development of India an increasing amount of refined sugar is being consumed in this country.

But while the market for refined sugar is expanding yearly, this by no means indicates that the demand for unrefined sugar or *gur* is decreasing. The general rise in wages and the increased value of agricultural produce have enabled a large number of cultivators and the labouring population to increase their demand for this commodity, and as things stand at present it looks as though the demand from this quarter will steadily increase. At any rate, as this form of raw sugar is both nourishing and cheap and enters into many Indian food preparations, it is safe to assume that for some considerable time to come the market for good *gur* will remain steady.

It is sometimes asked: can India, besides satisfying her demand for raw sugar, produce the 800,000 tons of white sugar imported from abroad? The official forecast of the current year's area sown with cane is about $2\frac{1}{2}$ million acres so that if India is to be made self-supporting the cultivation of this crop would have to be enlarged by about 25 per cent. on the existing cultivation, or manufacturing yields should be increased so as to produce the required quantity of both raw and white sugar. It will at once strike any one who has studied the conditions under which sugarcane is grown and jaggery manufactured in this country that the margin for improvement is so enormous that it is not necessary to take the land from other food crops to increase the total outturn.

In India with its $2\frac{1}{2}$ million acres under cane there is room for both *gur* and sugar. But the losses in extraction and manufacture should be brought down to a minimum. To give an instance of the waste taking place at present it is calculated that the amount of sugar burnt in the megass as fuel and the loss of sugar from direct heating over the fire is nearly equal to India's imports. This is one of the consequences of the cultivator assuming the rôle of a manufacturer which, it may safely be said, he has not taken up as a matter of choice or from natural aptitude. If the maximum quantity of white sugar is to be obtained factories run on up-to-date methods should be multiplied in tracts where cane cultivation is concentrated. These factories should put up powerful machinery for crushing cane so as to obtain the largest possible extraction, and evaporation should take place in vacuo and not in open pans.

It will thus be seen that while in all other sugar-producing countries attention is concentrated on the realization of the greatest amount of sucrose (white crystallizable sugar), in India we manufacture two sorts of product, *viz.*, pure refined sugar and jaggery or *gur*, which latter is a mixture of crystallizable and uncrystallizable sugar. The *gur* which is most prized for consumption generally has a light colour and good flavour. But it does not necessarily have a high standard of sucrose. There is a great variation in prices of jaggery throughout India which is to some extent due to differences in quality and appearance and also to local tastes and prejudices.

It may be noted that a good quality *gur* manufactured for direct eating is not quite suitable for refining. The good quality *gur* as mentioned above does not necessarily have a high sucrose content which is the *sine qua non* in the *gur* intended for refining. Further, in order to produce light coloured *gur* suitable for eating it is necessary that lime should be very sparingly used, while for the *gur* which is ultimately to be refined larger quantities of lime are required to produce a stable chemical composition. Juice of good colour and a moderate coefficient of purity is the best for good eating *gur*, whereas it should be of high purity for the manufacture of jaggery for refining. Soft and well crystallized *gur* is well suited

for refining. Extremely hard and burnt *gur* never goes through the refining process at all. While the production of sugar direct from the cane is to be encouraged, as it is more expensive first to make jaggery and then to refine it than it is to extract sugar direct from the juice, still it may not be out of place to mention that as jaggery can be refined with the loss of about 25 per cent. raw material in the process and as the crushing season lasts for about 4 months only and some factories use jaggery for the remaining part of the year to keep them going, any large increase in the manufacture of *gur* coupled with a fall in its price will enable the refineries to work at a profit and so increase India's production of sugar.

At present the refining industry is limited as the losses incurred in the refining of raw sugar are serious. Firstly, the quality of the raw sugar usually offered by cultivators for sale is so poor that it yields a low percentage of sugar when refined. Secondly, if the refinery is to be kept working throughout the year the raw material has to be stored with the resulting deterioration so that it not unfrequently happens that when refining nearly 50 per cent. comes out as molasses. This leaves very little margin of profit unless money is made out of molasses. It is said that in Java a large quantity of the molasses is allowed to run to waste, but the methods adopted in a country so favourably situated for sugar production cannot be recommended for use in one where a profit must be made out of everything if the industry is to get a firm hold. If the inverted sugar is utilized in the manufacture of spirits or denatured alcohol for industrial purposes, or if molasses is mixed with the megass and sold as cattle food or mixed with the meal from the oil-seeds and crushed and compressed into cakes or cakettes it will materially assist in the expansion of the industry in this country.

The increasing imports of foreign sugar have threatened with extinction that part of the indigenous sugar industry which makes white sugar from *rab*, an industry of some importance in the United Provinces.

To give an idea of the amount of waste occurring in the Khandasari system it may be mentioned that by this process about 3·33

maunds of sugar are obtained from 100 maunds of cane. By following up-to-date methods the Pilibhit factory obtains 7¼ maunds of sugar from 100 maunds of cane.[1] As it is not economical to make *rab* first and then to refine it, it would be much better if a number of cultivators in co-operation with the *Khandsaris* could purchase a steam power-mill and put up small factories at suitable centres. Mr. Hulme, Government Sugar Engineer Expert, has suggested that if funds allow a triple mill (nine rollers with crushers) extracting 90 per cent. would give the best results ; failing that, a six roller mill with an extraction of 80 per cent. may be installed. Its minimum crushing capacity should be 270 maunds per day, *i.e.*, about 80 acres in 100 days.[2] These factories will not be able to make sugar to compete with foreign sugar but they could supply such sugar as is now made by country methods for consumption by orthodox Indians and for which higher prices are paid than for factory-made sugar.

It is true that the larger the factory the better it pays. But that small-sized modern factories crushing about 100 tons of cane a day can be made to pay is evident from the successful working of the factory at Pilibhit which has been remodelled under Mr. Hulme's supervision. It is also suggested by Mr. Hulme that if a seed-crushing and oil-extracting plant were combined with the smaller sized factories so as to utilize some of the machinery and the skilled staff during the off season, small modern factories crushing about 1,500 of maunds of cane per day would also have a better chance of success. The seeds are locally available and a market both for oil and cakes can be developed.

II. Sugarcane Cultivation in India and its Improvement.

We may now proceed to a consideration of the defects in the present methods of sugarcane cultivation. The first point that will claim notice is the extremely low yield of cane per acre. In Java the average yield is 42 tons of cane per acre capable

[1] Hailey, H. R. C., "The Sugar Industry in the United Provinces." *Report of the Ninth Indian Industrial Conference*, 1913.
[2] *Agricultural Journal of In ia*, Vol. X, p. 59.

of yielding $4\frac{3}{10}$ tons of white sugar while in individual cases yields as high as 60 tons of cane are obtained. The Director of the Experiment Station at Pekalongan confidently looks forward to an average production of as much as 7 tons of sugar per acre in the future. In a favourable year one mill has actually reached that figure for one month's working. In Northern India 8-12 tons of thin cane and 14 tons of thick cane may be taken as an average yield per acre. The average yield is better in Southern India, being 25 tons of cane an acre with an average outturn of $2\frac{1}{4}$ tons of unrefined sugar.

Parts of Madras, Bombay and Mysore are well suited for sugar-cane growing, being well within the tropics with the temperature uniformly high throughout the year. The rainfall is however of such a nature that irrigation is needed to supplement it.

Thick canes predominate in these parts and yields are large. Great care is often taken in cultivation and the crop is heavily manured with oil-cake and good profits are obtained. To cite an instance. In the area under canals in the Bombay Presidency the net profits obtained from the cultivation of the soft yellow green variety *pundia* which requires plenty of manure and copious irrigation are from Rs. 100 to Rs. 200 or more per acre, 35 to 40 tons of striped cane per acre giving from 8,000 to 10,000 lb. of *gur* being obtained in 11 to 12 months after planting. Yields of 40 tons of cane and 12,000 lb. of *gur* are not uncommon. Its analysis as given in *Bulletin No.* 61 *of the Department of Agriculture, Bombay*, is:

Sucrose in 100 lb. cane	15·310
Reducing sugar in 100 lb. cane	0·672
Fibre in 100 lb. cane	10·407
Moisture in 100 lb. cane	72·521
Ash and nitrogenous matter in 100 lb. cane ..	1·090

But though the quality is so good the crop is relatively unimportant in Peninsular India. The area under it is small and is limited by the amount of water available and the quantity of paddy grown and there are no indications pointing to any very large

increase in cane cultivation in those parts except where new irrigation facilities have been provided. The case is different in Northern India where the United Provinces, Punjab, Bihar. Bengal and Assam claim nearly 90 per cent. of the acreage under this crop. As this region is outside the tropics the amount of warmth and especially the length of the growing period are insufficient. While the field canes in Southern India are often comparable with those of tropical islands in thickness and vigour, those of North India are much thinner, more fibrous and much less productive of sugar. The cultivation of sugarcane in the south is intensive and costly; the crop in the Gangetic plain has very little attention paid to it.

The question now arises whether success may not be obtained most rapidly and economically by replacing the inferior canes in North India with better kinds. Dr. Barber has touched upon this point in his article on "Some Difficulties in the Improvement of Indian Sugarcanes."[1] There are four ways in which the improvement of local canes may be attempted. One is by the introduction of exotic canes which have proved of value elsewhere This method has proved successful in Madras, where the striped Mauritius and Barbados seedling cane No. 208 introduced in the Vizagapatam district have come into great favour with the cultivators. The introduction of the red Mauritius cane through th Samalkota Agricultural Station has revived sugarcane cultivaion in the Godavari District. The same variety has also supplanted the local striped cane in parts of South Arcot.

In the United Provinces a Java variety known as 33 is being grown by Mr. Clarke on the Government Sugarcane Farm at Shahjahanpur and gives promise of becoming a very suitable cane for those parts if not for other regions in North India. It has also been found that selected varieties of thick canes can be grown in these Provinces if proper cultivation and irrigation are given. These canes are much cheaper and easier to work from the manufacturing point of view and have a higher sucrose content

[1] *Annals of Applied Biology*, Vol. I, Nos. 3 and 4.

and give a heavier crop than the *desi*. As an instance a Mauritius variety, Ashy Mauritius, may be quoted. This variety was selected from a number of imported varieties and has been grown for some years under the best and most intensive cultivation possible. In 1912 it yielded under these conditions 30 tons of cane and 101 maunds of *gur* per acre and contained 13·05 per cent. sucrose in the canes while the local *ukh* varieties were only giving 30—40 maunds of *gur* per acre.

At Jorhat in Assam three Barbados varieties B. 147, B. 208, B. 376 and striped Mauritius have shown their superiority as producers of high purity juices and these are being planted on the special Sugarcane Experiment Station in North Kamrup.

But this method has limitations which are mostly due to the inability of these introduced canes to stand adverse conditions of local agriculture.

The second method is the transfer of canes from one part of the country to another. This has been tried and met with limited success mainly because the introduced canes cannot hold their own against the best local kinds which are themselves the outcome of centuries of selection by the cultivators. The improvement of local canes by selection and the observation of sports and the production of seedlings are the most promising lines and are receiving special attention at the hands of Dr. C. A. Barber, Government Sugarcane Expert, who has raised over 40,000 seedlings during the past two years at the Government Farm, Coimbatore. It is hoped that in course of time a few all-round useful canes will be available for supply to Agricultural Stations in the North for a renewed series of tests there before they are given out to cultivators.

Certain practical conclusions arrived at by the Agricultural Departments may now be briefly stated. It has been proved that sets from plant cane are superior to those from ratoon cane and that the use of terminal sets for planting will produce more vigorous growth of cane than sets of any other part of the stalk. In Java some fresh tops are brought to the plantation every year. More attention should, therefore, be paid to the choice of sets for planting. The number of sets planted per acre can also be

reduced with advantage in certain parts. Again the quantity of water used for irrigation is excessive in some parts. Manuring should be on a more liberal scale, and calculated to supply as much nitrogen as is absolutely required. In the Deccan canal-irrigated tracts the tendency is to apply more nitrogen than is required.

The line of improvement in Northern India seems to be better cultivation, especially in the direction of ridging and drainage, liberal use of manures, including oil cakes, green manuring and introduction into suitable localities of better varieties which not only give higher yields but are also more resistant to disease.

III. EXTRACTION OF THE JUICE AND ITS CONVERSION INTO *gur*.

We may now turn to a consideration of the extraction of the juice. The old wooden and stone mills for crushing cane have by this time almost everywhere been supplanted by iron mills with the result that the percentage of extraction has risen. But even now there is much scope for improved milling. At present much of the juice passes away in the megass because these rollers have a tendency to assume a slightly concave form after they have been in use for any length of time and this leads to a deterioration in milling efficiency. The metal of which these mills are made is soft. It would be interesting if, as suggested by Mr. Shakespear of the Cawnpore Sugar Works, a trial were made with case-hardened steel rollers, if this has not already been done, with a view to test whether uniform milling efficiency is thereby obtained. These mills are more costly, but if they are found successful in extracting more juice it will not be difficult to arrange for their gradually replacing the present mills.

Mr. Clarke, the Agricultural Chemist to the Government of the United Provinces, carried out interesting experiments at the Partabgarh and Shahjahanpur Experiment Stations, with regard to the efficiency of small iron mills at present in use in India. The results have been published in *Pusa Bulletin* No. 42. These show that a very high extraction can be secured if the *best type* of 3-roller bullock mill is working *properly*. For single dry crushing it is doubtful if it could

be exceeded by any type of mill. But to secure this the strain on the bullocks is great and the rate of crushing slow. The cultivator with his light and underfed bullocks slacks off the mill and the result is inefficiency in extraction.

It is generally the case that when planting cane a ryot is guided by the amount of bullock power he has at his command for crushing it. The case for power crushing is therefore strong as it not only eliminates the losses occurring in juice extraction by bullock mills, does the work more quickly and at a much cheaper rate and gives relief to the overworked bullocks at a time when other agricultural operations require their services, but will also enable the cultivator to put down the maximum amount of land under sugarcane and will lead to a concentration of the cultivation in the near future.

In modern factories we have multiple Roller Mills weighing some 700 tons for crushing cane, whilst in comparison with these the bullock mills of India are such that a strong man can lift them. As mentioned by Mr. Hulme these multiple Roller Mills extract some 30 per cent. more juice from the cane and from this it is obvious that any scheme to improve the indigenous methods of the production of jaggery must include power-driven mills, for there are few industries in any part of the world which will stand a deliberate 30 per cent. loss of material which has to be charged to one stage of the operations—crushing, and with an industry in a by no means consolidated position like that of sugar in India, such a waste at one stage seriously imperils the whole undertaking from a financial point of view.

In parts where sugarcane is not sold direct to sugar factories it would seem that the best road to an improvement in the extraction of juice and jaggery manufacture lies in the fostering of the co-operative principle so that the crushing of the cane can be concentrated and scope may be found for the working of small power plants with more efficient evaporating appliances.

Evaporating plant for dealing with large quantities of juice in the making of *gur* is at the present moment in a state of evolu tion. The old Fryer's concretor is considered very satisfactory in its results as far as quick evaporation is concerned, but it is doubtful

if it could effect a complete defecation and evaporation of the juice without fuel beyond that supplied by the cane. It is understood that there is a new apparatus on the market which has been installed with satisfactory results in Formosa for making Chinese sugar which corresponds to a certain extent with our Indian *gur*.[1]

The manufacture of *gur* as carried out by cultivators suffers among other things from the overheating of the juice causing carameliza-tion and inversion caused by acidity of the juice. It may, however, be mentioned that some improvements in the boiling pan and furnace have been made in India. As the result of his experi-mental work Mr. Chatterton has evolved a system of manufacturing jaggery in small power-driven mills the use of which will enable the sugarcane growers to obtain 30 per cent. more from their cultivation than they have hitherto done. Mr. Chatterton has described in some detail his latest type of jaggery furnace in which there are four sets of three pans in tiers. Each tier of pans is heated by one furnace to which no firewood but only dried megass is fed. An abstract of the work of such a furnace with average cane is as follows :—

The lower pan in which the jaggery is finally formed can be emptied every 1½ hours. An average output of 6,250 lb. of jaggery per day of 24 hours can be turned out. The engine is 12 H.P. The mill has 12″ × 18″ rollers and can crush 1 to 1½ tons of cane per hour. Much, however, depends on the skill of the men feeding canes into the mill. The actual cost of making jaggery by this plant according to Mr. Chatterton is annas 2 per 25 lb., while according to ordinary methods it would cost not less than 4 annas for the same quantity. The minimum quantity of cane which such a plant must crush in a season to pay for manufacture, depreciation, and interest is about 1,500 tons. It would therefore seem that about 150 acres within reach are required in Northern India to make its use profit-able. About 75 acres will do in Southern India as the yield there per acre is comparatively heavier. If the power-driven mill be worked by a number of cultivators on a co-operative basis it would

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[1] Neilson, W. "Note on Indian Sugar Industry." *Proceedings of the Board of Agricul-ture in India*, 1911, p. 88.

pay them to instal a smaller size mill for so small an area as 40 acres in Southern India.

A few power mills are now in use in some parts for *gur* making. In 1912 a trial central jaggery manufacturing station was installed by the Director of Industries, Madras, at Singanallur in which greater rapidity of milling and the complete saving of firewood are attained. In Mysore there are at present ten sugarcane crushing plants driven by gas or oil engines and it is anticipated that about ten more will be started during the next few months. At least ten power cane crushers are at work in the Bombay Presidency and the use of improved furnaces and more economical crushing mills is being successfully demonstrated by the Local Department of Agriculture. The charges on these power plants can be very largely reduced if something were done with the engine in the off season such as attaching rice hulling or oil-pressing machinery to these plants.

As regards the prolongation of the crushing season by arranging varieties of cane at different times of planting, etc., it appears that Dr. Barber had tried it at Samalkota without success and Mr. Neilson, the Manager of the South Indian Sugar and Distilleries Co., had done the same in South Arcot. The cane did not grow properly and the most they could do was to get a four months crushing season.[1] In Mysore it appears that the crushing season is longer. In Bihar Mr. Taylor has found that while the canes known as *Khari* and *Shakarchynia* ripen very early and give good sweet juice even as early as December, dwarf canes such as *Mango*, *Hemja*, and *Rheora* ripen more than a month later when grown under the same conditions of cultivation. These dwarf canes in fact were found not to ripen till the middle of February and showed their maximum sugar content early in March. It would therefore seem that the judicious selection of varieties will help to prolong the period of working of a Central Factory in Bihar.

Cane in the Central Provinces is ordinarily planted from January till the end of March. But the results of experiments (*vide* Messrs. Clouston and McGlashan's article in the *Agricultural Journal*

[1] Proceedings of the Agricultural and Trade Conference, Madras, December 1914, p. 154.

of India, July 1915), have shown that cane planted in October gives a much larger yield than that planted in February and March as practised locally. When planted in October it gets a good start before the hot weather sets in and being 4′—5′ high in February escapes the damage arising from stem-borers and red rot during the months of February and June. This indicates that there is scope in the Central Provinces for the extension of the planting season. A factory situated in a favourable locality in these parts would thus be able to prolong its working season.

IV. Central Factory System.

There are two systems under which sugar is grown and made, one the "plantation" system of the West Indies, the other the "Central Factory" system which is a more recent one introduced in various countries. In the Plantation system, the land, the agricultural labour, the factory and the manufacturing capital, are all under one control. In the Central Factory system, with its various modifications, several independent people are bound to assist one another by legal contracts. As shown in *Agricultural Ledger* No. 12 of 1903 by Messrs. Burkill and Weinberg, there are four types of Central Factories in the sugar-producing countries: (1) co-operative central factories, cane-purchasing central factories, (2) without land and (3) with land, and (4) land-hiring central factories. In co-operative central factories, the shareholders are cultivators of cane who by joint subscription put up a factory which is in the charge of an expert manager, controlled by the Board of Directors, elected by the cultivators. It will be seen that the system of co-operative central factories in which the outside capitalist is eliminated requires capital and a developed sense of mutual trustfulness on the part of those who combine to work it, and can only be adopted where those co-operating are engaged in cane business only and have their own estates on which they can raise if necessary the capital required.

In some of the West India Islands another form of co-operation is also practised. Briefly the arrangement is this.[1]

[1] Note on Indian Sugar Industry and Modern Methods of Sugar Manufacture. *Bulletin No. 60 of the Dept. of Agri., Bombay*, 1914.

"The capital required for equipping the factory is raised by debentures bearing 5 per cent. interest. All the debentures are to be amortised in 15 years. Every debenture holder receives a certain number of ordinary shares as fully paid up. The cane growers enter into contract with the factory for keeping a certain area under cane. The factory pays a definite price for the cane. After paying the manufacturing expenses, the interest on debentures and addition to the sinking fund the net profits are equally divided between the cane growers and the shareholders.

"The principal idea of both these arrangements is that a full price is paid to the cane planters for the supply of cane. The capitalists supply money for the factory and work the factory in trust. When in 15 years the capital investment is paid off the capitalists and the planters become equal participators in the assets and liabilities of the company as well as the profits. The planters lose nothing. They get full price for their cane and as an advantage of co-operation they get half the assets in the company and share half of the profits. While on the other hand the capitalists get back all the money invested and for the risk they had incurred in investing the money they get half the assets of the company and share half the profits; so that both get full advantage of the co-operation and lose nothing."

In the case of purchasing factories they may either be factories buying the cane from cultivators or hiring the right to grow it as they desire on the land of others. The cane-buying factories exist in many parts of the world, including India. The land-hiring central factory system is the system of Java. Experience has shown that cane-purchasing factories having no land gradually develop into those owning or hiring land, to enable them to make certain of a supply of cane and also to get the best variety at the most suitable time.

This method is more businesslike than the former, for the following reasons:—

1. The land is under factory control and run for the factory, whereas the ryot grows only as much sugarcane on his land as he can spare after making provision for his other requirements.

2. All cultivation is done under supervision of experienced men, done at the right time and in the right way. The ryot may, on the contrary, be a good or a bad farmer and his crop results vary accordingly, with the result that the factory has to take over a mixed lot of cane.

3. The dates of the crops are fixed months ahead, and the factory in consequence can work for periods planned beforehand to be at once economical and convenient.

It takes little acumen to realize that a factory following this method can outdo another having no guarantee for the sufficient supply of cane at fair rates and it becomes a problem how to keep the factory paying and the ryot in that state of freedom and independence which is the *sine qua non* of a flourishing agricultural population. In Java and Formosa where the sugar industry pays best, practically speaking, facilities are given to sugar mills at the expense of the cultivators.

We may now turn to a consideration of the question where central sugar factories of the modern type can be established in this country. The tracts where the cultivation of sugarcane is concentrated are parts of the United Provinces and Bihar. The area under sugarcane is rising in the United Provinces and as the increasing imports of foreign sugar have led to the abandonment of a large number of small indigenous factories which formerly made sugar from *rab*, more of the cane crop is available for conversion either into *gur* or the manufacture of sugar direct. Here the cultivators are not unaccustomed to selling their cane and it will not be a difficult matter to get sufficient supplies of cane, provided the factory pays the cultivator as good a price for the cane as he gets at present from the conversion of his cane into *gur*. The cultivators are accustomed to taking advances, but this the factory can afford to give as it materially strengthens its own position and control thereby. The quality of cane is somewhat poor, but considering the rate at which cane can be purchased in these parts it has been found that a central factory can work with profit. The geographical situation of the United Provinces which are far removed from the sea is also an advantage as the heavy transport charges on the

imported foreign sugar act as a sort of protection to the indigenous product. If some sort of mechanical transport were adopted it would considerably reduce the transport charges and also enable the cane to reach the factory in good condition. At present, cultivators bring their cane to the factory in bullock carts—a slow and costly method of transport—very inconvenient for the factory to handle.

The Gorakhpur Division in the south-east of the United Provinces supplies the cheapest form of *gur* and exports about 10 lakhs of maunds of this commodity. About one-third of this finds its way to the Cawnpore refineries. The price is invariably low, rarely exceeding Rs. 3 and falling as low as Rs. 2-12-0 or Rs. 2-8-0. In 1912, prices fell to such a point that it did not pay to manufacture the cane into *gur* and some of the crop was, according to Mr. Hailey, fed to cattle. A central factory in these parts would, in the opinion of Mr. Hailey,[1] "probably be a boon to the cultivators in providing a steady market for their cane and a more profitable means for its disposal than by converting it into *gur*. If there is a profit to the refiner who has to transport his raw material long distances by rail and employ expensive fuel in refining, there should *primâ facie* be openings for properly equipped cane-crushing factories on the spot. As the surplus of *gur* and country-made sugar available for export, after satisfying local consumption from this trade block amounted to some 17 lakhs of maunds, there should be no lack of cane."

The same author has, however, pointed out that in the Upper Doab and in Bijnor and Bara Banki districts a Central Factory would have little chance of success owing to a well-established and profitable export trade in *gur* and the prohibitive price of cane.

At Bubnoulie in the United Provinces a Central Factory has been set up with a capacity of from 400 to 600 tons. In Bihar 8 Central Factories have in recent years been erected. The erection of two or more factories is in contemplation. The production of sugar in Bihar is paying and an extension of the industry is likely as the conditions here are favourable for the Central Factory system.

[1] "Prices of Gur and Cane in the United Provinces." *Agricultural Journal of India*, Vol. IX, p. 225.

In the Kamrup and Goalpara districts of Assam there are tracts of waste land approaching 50,000 acres which are supposed to be suitable for sugarcane growing on a large scale. Here the question is not one of finding water for irrigation which if required could be arranged either from the numerous streams or from wells, but one of drainage which requires careful attention before any good results can be hoped for. In North Kamrup an area of about 1,000 acres has been taken up by the Agricultural Department for the initiation of an experiment in sugarcane cultivation by means of steam tackle, the object in view being to ascertain at what cost per maund cane can be produced. It is estimated that if cane can be produced at annas 5 or less per maund of 82 lb. the manufacture of white sugar by a large factory will yield a handsome profit. In the event of the experiment proving successful it is intended to hand over the concern to capitalists who will increase the area under cane and build a sugar factory on the spot. Funds have been provided for carrying on the experiment for three years but if sufficient proof of success is obtained earlier the concern will be disposed of.

In the Mon Canals area in Burma a Rangoon firm has undertaken to conduct an experiment in sugarcane cultivation under the supervision of an expert from Java with a view to discovering the suitability of the tract for sugarcane cultivation on a large scale and the erection of a factory equipped on the most modern lines. The Local Government have agreed to meet half the cost of the experiment up to a maximum of Rs. 10,000.

In the Central Provinces a lease of about 4,600 acres of Government waste land, untrammelled by any rights of tenants, has been given to Mr. McGlashan of Cawnpore, with a view to the formation of a company. Extension of sugarcane cultivation is possible in parts of these provinces where facilities for irrigation can be provided.

One of the reasons why the manufacture of white sugar in India is not making any substantial headway is that a factory in order to be successful must be large enough, and this entails a

large initial outlay. It also requires a large expert staff to work it.

In Egypt only factories with a capital of as much as £200,000 have survived and even they have found it necessary to own and control 20 per cent. of the necessary cane-growing area to steady the market, the small factories working on the system of control by advances having failed.

In India sugarcane cultivation is scattered and the quantity grown every year is subject to variation. Big sugarcane estates are practically absent except in some parts like Bihar, and the formation of new estates in the midst of areas already under specialised and highly paying crops is practically out of the question. Modern sugar factories here have therefore to deal with numerous small holders and are thus dependent upon a large number of cultivators ignorant of the business methods which a factory has to adopt. Success will depend upon the extent to which good-will and co-operation of these cultivators is secured by the manager of the factory. In Java and the British West Indies every factory either owns or has managing control over 4,000—5,000 acres of sugar plantation and can thus ensure the steady supply of raw material. In other sugar-producing countries where this is not possible and cane has to be purchased from individual planters the holdings are fairly large and the farmers are usually educated businessmen who understand how to deal with the factory in a business-like way. Even where cane has to be purchased from small holders it is only a small portion of the total cane supply.

It must, however, be said that the difficulties mentioned above are not insuperable in the United Provinces and Bihar, and that they have been overcome will be seen from the successful working of the factories established there. It is true that where cane cultivation is not concentrated but very much scattered all idea of sugar production must be given up. There and in Bombay, Central Provinces, Mysore and parts of Madras where the manufacture of *gur* pays better than sugar the working up of the cane into raw sugar must continue, but even in this there is much room for improvement.

The efficiency of large factories at work in India compares favourably with that of factories in other countries, but the raw material they have to work with is not of the same quality and it is much affected by annual weather disturbances. The indigenous *ukh* and *ganna* varieties, commonly grown, contain from 9 to 11 per cent. of sugar varying with the season. But the quality and amount of fibre is such that high extraction is not so easy as with varieties like Rose Bamboo and the thick Mauritius canes. The problem of producing white sugar will be much easier to solve if the outturn of sugar per unit area is increased by improving and intensifying the cultivation and if better varieties are selected with reference both to their actual sucrose content and their workability in the factory. It is believed that such improvements are possible even though they may take time.

Java has numerous advantages over India in the matter of cane cultivation, not the least of which is climatological. The scientific excellence of the Java sugar factories, their managers and their workmen, has long been well known. They fought through the difficult period of the sugar bounties competition triumphantly. The making of good dry white sugar direct from the cane juice is no easy matter. "Its manufacture," in the words of Dr. Geerligs, "demands not only a good knowledge of general sugar manufacture, but also special skill on the part of manager and workmen and above all a large capacity in all departments of the sugar house and a proper arrangement of the whole plant. The plant should be well designed and well constructed, and the staff and workmen should understand their work. Even the best process of white sugar manufacture will fail where the machinery is inadequate or the men incapable." In India, in the past, factories were opened which were in some cases not up-to-date and in some cases far from railways, in others far from sources of supply of raw material, and above all, they were not all under the supervision and management of practical factory managers with the requisite amount of skill and experience. Matters are, however, improving, and there are factories now in Bihar which in their working will compare favourably with some of the best factories in the world.

V. Palm Sugar.

As India's production of palm *gur* and sugar is close on half a million tons and as this industry is capable of improvement a brief notice of the same is here necessary. In parts of Central India date trees grow wild but practically speaking the juice is not converted into *gur* or sugar. The cultivation of date palms is an important industry in Bengal. Palm *gur* and its products are largely consumed in the districts in which they are made, but in the Jessore district there are many refineries. Most of the sugar refined in Jessore goes to Calcutta and is largely used for the preparation of native sweetmeats. Mr. H. E. Annett has thoroughly investigated the condition of the date sugar industry in Bengal and published the results in the *Memoirs, Department of Agriculture, India, Chemical Series*, vol. II, no. 6. A few of his suggestions are here mentioned.

At present only 240 trees per acre are usually grown, giving a yield of 2·3 tons of *gur* but by the regular planting of 350 trees per acre an average of 3 tons of *gur*, per acre, can be obtained. It has been found that the thickest trees are the largest yielders; hence the sowing of selected seed from such trees is well worth experimenting. In the manufacture of *gur* also there is room for much improvement. The use of dirty earthen pans in which the juice is boiled is to a large extent responsible for the dark colour of the date *gur*. With iron pans jaggery of very fine quality can be produced. The aid of the principle of co-operation among date growers is here indicated. The present method of refining by means of water weed is an exceedingly slow process. If centrifugals were introduced the process would be much quicker and the turn-over much greater. The juice exuding from a freshly cut surface of the date tree contains only sucrose. Inversion takes place afterwards while it is standing in the pot overnight. Mr. Annett recommends washing the cut surface of the tree with formaline once a week and the addition of a small quantity of formaline to the pots daily. Treated in this way a very appreciable increase in yield of sugar per tree might be obtained. The

substitution of cheap metal pails for the earthen pots is also recommended.

The present writer is inclined to think that if, as suggested by Mr. A. E. Jordan[1] in 1906, small steam plants for converting the juice into sugar were put up in the centres of the date tree cultivation and arrangements made to collect the juice from numerous cultivators in a tank which was then immediately treated with formaline with a view to prevent inversion, the position of the industry would be improved.[2]

In the Southern Districts of Madras and in Upper Burma the juice of the palmyra palm is converted into *gur* which is largely consumed locally. In other parts of India its juice is utilized mainly in the form of toddy, an intoxicating drink. If the value of this juice as a sugar producer be brought home to the people in these parts more interest is likely to be taken in the extended cultivation of this palm resulting in an increased output of sugar in this country.

In Madras besides the palmyra, the date-palm and the coconut are also tapped for the manufacture of sugar. But the only attempt to organize tapping and to manufacture sugar commercially direct from the juice is the factory at Kulasekharapatnam belonging to the East India Distilleries Co.

VI. Conclusion.

To conclude : It will be seen on a comparison of the figures of the last five years with those of the preceding quinquennium that substantial increase has taken place in the acreage under this crop

1 "Indian Sugar Development." *Report of the Second Indian Industrial Conference*, 1906, pp. 227-28.

2. Since this was put in type the writer has come across the following in the recent report of the Bengal Department of Agriculture.

Government has sanctioned the purchase of a small apparatus from America such as is used there for the production of maple sugar. The plant ordered should deal rapidly with the juice of a large number of date trees. It is now on its way and is to be tried next cold weather in the Jessore District. Metal collecting buckets for the juice are also being imported. It is also proposed to collect the juice from the pots in large gathering tanks. These will be transported from distant gardens in carts or boats to the sugar-making house. This should save much labour.

in Northern India. In Bihar and parts of the United Provinces new factories on up-to-date lines are springing up and making the business pay. The Government Sugar Engineer Expert, Mr. Hulme, is able to guide the owners of prospective factories in the selection and installation of the most efficient kind of machinery. It should not, however, be supposed that results can be obtained in a short time, but now that the problem is being attacked systematically from several aspects substantial improvement in the Indian Sugar Industry will result in course of time. It is likely that capitalists will see their way to erecting new factories in Bihar and eastern parts of the United Provinces as the supply of cane is reasonably assured at a price which, while remunerative to the cultivators, will also enable the factories to work at a profit. As a matter of fact there are factories in Bihar, which procure good cane by purchasing in advance from cultivators and obtain excellent results. The cultivators in the neighbourhood of such factories are saved the trouble of crushing their cane and converting it into *gur*. The strain on their bullocks is thereby lessened and they are enabled to attend to other agricultural operations. In these days of specialisation the cultivator should not undertake the rôle of manufacturer as he is sure to do it badly. The factory owner should try to have at least some few acres under his own plantation and then try to increase the outturn by better cultivation, more liberal use of manures, introduction of better varieties, etc. The cultivators, when they see such results, will in course of time adopt the improvements and this will be to the material benefit of both.

Nowadays competition is so keen and prices are so cut that every possible aspect has to be considered, and in many cases it is only by the fortunate discovery of a by-product that an industry is enabled to carry on. Java has everything in its favour and will certainly not lose the Indian market without a struggle, and it is therefore up to India to face the problem—either to run the industry as a business—to make a profit irrespective of everything else, or to continue as now a state of things which cannot lead to success when put in the field against such powerful and well organized rivals.

Here in India we have an industry which badly needs more capital to enable it to expand and the fact that the Agricultural Department's experiments and the assistance available from Government sugar experts has made it possible to overcome many obstacles which formerly obstructed progress, should greatly assist in the bringing in of fresh capital which is essential to development.

A NOTE ON THE DIAGNOSIS OF GLANDERS.

BY

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IN equines that become infected by the Glanders organism, the development of external symptoms of the disease is usually slow, so that only in a small proportion of cases is diagnosis possible by clinical examination alone. Since, however, affected animals, that are apparently healthy, are capable of spreading the disease not only to other animals but also to human beings, the urgent necessity of detecting and eradicating such centres of infection is very evident.

The discovery of Mallein by Helman and Kalniny in 1891, and its application by subcutaneous injection marked a great advance in the means available for the diagnosis of latent cases of the disease.

The various forms of Mallein are all prepared from cultures of the Glanders bacillus (*B. Mallei*) and contain substances which when introduced into the body of a glandered animal, provoke a general febrile reaction and symptoms of local inflammation at the seat of inoculation. In healthy animals Mallein produces little or no reaction.

The subcutaneous method of applying the Mallein test has been relied upon almost solely in Great Britain for the suppression of the disease and the results obtained during the past ten years are certainly sufficiently convincing to warrant the confidence with which the test is regarded; the number of outbreaks, as recorded in the

Board of Agriculture report for the year 1914, has fallen steadily from 1,529 in 1904 to 162 in 1913 and 97 in 1914.

It had early to be admitted however that, in addition to certain recognised conditions under which the Mallein test is unreliable, there were a small percentage of infected animals which failed partially or completely to respond to a subcutaneous injection of the agent.

Accordingly, numerous investigators sought to find other means of diagnosis to replace or supplement the subcutaneous test and several interesting and delicate methods were devised. Some of these depend on the demonstration of specific substances in the blood serum of infected animals, but since they are essentially laboratory tests, their description is outside the scope of the present article.

The two methods to be described are modifications of the Mallein test which owe their characteristic features to the sensitiveness of the tissues surrounding the eye, and the inflammatory response produced in glandered animals by the introduction of Mallein into these tissues; they are known respectively as the "Ophthalmic" or "Conjunctival" and "Intra-dermal-palpebral" reactions.

The ophthalmic test was introduced in 1907 by Vallée and quickly gained favour on the Continent and in America as a reliable and easily applied diagnostic method for use by practitioners and State veterinarians. It is now the official test in the United States, Austria, Bavaria, Denmark and other countries where it has almost entirely superseded the subcutaneous Mallein test. In cases of doubtful reaction, the older test is sometimes employed, but the usual practice is to send serum from the suspected animal to the laboratory for testing by one or other of the more delicate serum methods of diagnosis.

For the ophthalmic test specially prepared concentrated Mallein is required; this is supplied in the form of a dark brown viscid liquid or as a light brown powder (Mallein siccum) which must first be dissolved in a definite quantity of sterile water, supplied with the powder. Before applying the test both eyes must be examined to

PLATE I.

OPHTHALMIC TEST.
PONY 105.
Eye reaction 18 hours after application of Mallein to conjunctiva; purulent discharge and partial closure of eye.

INTRA-DERMAL PALPEBRAL REACTION.
PONY 132.
Twelve hours after injection of *O·2 c.c.* of Mallein. Note swelling of lower lid and purulent discharge.

INTRA-DERMAL PALPEBRAL REACTION.
PONY 121.
18 hours after injection of *O·2 c.c.* Mallein into lower lid; eye closed; slight purulent discharge.

ascertain that no inflammation already exists ; if this is found, the test should not be carried out. Provided the eyes are normal, two or three drops of the Mallein are introduced within the eyelids; this may be done with the aid of an eye-dropper or, preferably, on a camel hair brush, the inner surface of both the upper and lower eyelids being gently smeared with the liquid. Only one eye is treated, the other serving as a control for comparison of the reaction.

Immediately after the application there will be some lachrymation and reddening of the conjunctiva, but these symptoms will disappear in an hour or two, and in a healthy animal nothing further will occur.

In a glandered animal, the characteristic reaction commences usually about the sixth hour and lasts from twenty-four to thirty-six hours or longer. It consists of a purulent discharge from the conjunctival sac which collects at the inner canthus of the eye in yellowish lumps and may run down over the face ; there is also reddening and some swelling of the conjunctiva, with occasionally gluing of the eyelids. To judge the result, the tested animal should be examined from twelve to twenty-four hours after the application of the test. The reaction varies in degree in different animals but only a purulent yellow discharge is to be considered positive of Glanders. When there is nothing more than a greyish slimy discharge and slight inflammatory reaction, the case is doubtful and a second application may be made to the same eye in 24 hours when a definite conclusion can usually be arrived at. If not, the subcutaneous test may be carried out or the ophthalmic test repeated in two or three weeks. Care must be exercised to ensure that the attendant does not wipe away any discharge that may occur. Only in a proportion of cases, usually those giving a marked eye reaction, is there any febrile disturbance so that in practice it is not necessary to record temperatures. The existence of slight fever does not interfere with the application of the test.

The ophthalmic test may be applied 24 hours after the subcutaneous test has been performed, but is more reliable if carried out before the latter : the subcutaneous test influences to some

extent a subsequent ophthalmic test and may seriously affect later serum tests, but the ophthalmic test has no effect on any other diagnostic method that may be carried out afterwards; this is one of its chief advantages. The ophthalmic and subcutaneous tests may be carried out simultaneously but during the height of the fever reaction the conjunctival symptoms may cease, usually, however, to appear again when the fever subsides. In cases where an ophthalmic reaction is followed within two or three days by a subcutaneous test, it will frequently be observed that inflammatory symptoms again appear in the eye that was previously tested.

A drawback to the employment of the ophthalmic test in India is the frequency with which animals show slight conjunctivitis, the result most probably of the entrance of dust; in such cases the subcutaneous or intra-dermal-palpebral test will have to be carried out.

In mules the subcutaneous test appears to be less reliable than in horses, so that in addition to the simplicity of its application and the avoidance of the troublesome process of temperature taking, the ophthalmic test would seem to be particularly suitable for application to these hybrids; where large numbers of equines have to be tested rapidly, as at Remount Depôts, the method could also replace the subcutaneous test with advantage.

The intra-dermal-palpebral test is the latest form of Mallein application and was first suggested by an Italian veterinarian, Lanfranchi, in 1914. It has been employed very largely in France during the past year and reported on most favourably. The method is really a combination of the subcutaneous and ophthalmic tests and unites the advantages of both without, it is said, their disadvantages.

The ordinary Mallein, as used for subcutaneous mallination, is employed, but the dose given is only 2 minims or 0·125 cc. instead of 1 cc. as in the older method.

The dose being small, a 1 cc. syringe, Record or other reliable pattern, graduated to $\frac{1}{10}$ cc., is necessary and care should be taken not to inject more than 0·2 cc. of the Mallein. The injection is made into the depth of the skin of the eyelid, usually the lower, though it appears to be immaterial if part of the dose is injected

into the loose connective tissue between the skin of the lid and the conjunctiva; for this purpose a fine short needle is required, such as is used by human surgeons or dentists; in this case few horses make much objection to the insertion of the needle. To avoid risk of piercing the lachrymal sac, it is well to direct the point of the needle backwards when injecting the lower lid.

In animals free from Glanders, a slight swelling of the injected lid may persist for a few hours, but this will have disappeared by the twelfth hour.

Glandered animals exhibit a characteristic reaction which commences about the ninth hour, reaches its maximum between the twenty-fourth and thirty-sixth hours, and may persist for three or four days. The injected eyelid becomes swollen and painful and the other eyelid may become similarly affected. The conjunctiva is inflamed and a muco-purulent discharge accumulates at the inner canthus of the eye; the œdema of the eyelid and sensitiveness to light causes partial or complete closure of the eye.

The reaction resembles that obtained by the ophthalmic test, but owing to the swelling of the eyelid is more pronounced and persists for a longer period. At the same time there is a thermic reaction similar to that following a subcutaneous injection of Mallein; this appears to be much more constant than in the ophthalmic test so that temperatures may with advantage be taken at the usual intervals. When a doubtful reaction is obtained the test may be repeated on the other eye, forty-eight hours later.

The subcutaneous test should not precede or follow the intra-dermal-palpebral test by a shorter interval than three weeks, but the two tests may be applied simultaneously without any interference with the reactions of each.

The experience in France is that this test is more reliable than the subcutaneous test, requires a smaller quantity of Mallein and may be carried out without the labour of recording temperatures at short intervals; one examination twenty-four hours after the injection is usually sufficient to arrive at a definite conclusion.

Moreover, in a country where the high atmospheric temperatures and exposure to sunlight have a marked effect on body

temperature, thermic reactions cannot be relied upon, so that an unmistakable local manifestation is of great advantage; the most striking and reliable is undoubtedly obtained by the intra-dermal-palpebral method, when accurately applied.

Concentrated Mallein for the ophthalmic test, as well as the ordinary variety for the subcutaneous and intra-dermal-palpebral tests is supplied from the Imperial Bacteriological Laboratory, Muktesar, United Provinces.

CLOVER AND CLOVER HAY.

BY

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I. Introduction.

One of the chief factors which limits production, in the soils of the Quetta valley, is the amount of organic matter. Immediately the proportion of this substance is increased, either by direct manuring or by the cultivation of crops like lucerne, growth becomes more vigorous and rapid and the yield materially improves. In the case of wheat, for example, the average yield of the unmanured, irrigated crop is about thirteen maunds to the acre while considerably over twenty maunds are often obtained from similar land that has been fertilized. Heavy dressings are applied to the fields near the main roads within a three-mile radius of the Cantonments, where the storage of stable manure is not permitted. Outside these areas, there is a marked falling off in production, and, where the land is only occasionally manured, the wheat crops are poor.

The physical effect of an increased supply of organic matter in the soil is two-fold. In the first place, its porosity is improved and gaseous interchange between the atmosphere and the soil is accelerated. But for the organic matter, the fine particles of the silt-like soils of the valley would pack so closely after surface irrigation as to deprive the soil organisms and the roots of crops of a sufficient

supply of air.[1] In the second place, the tilth and water-retaining power of the land are improved.

The need of a fresh source of organic matter in these soils is clear. The amount of manure is limited and is likely to remain so while the benefits of a lucerne crop are restricted by the fact that it remains in the ground for five or six years and is thus of limited value as a rotation. Some crop, preferably a leguminous annual, which can make use of the winter rains and which can be used as a green manure is therefore needed to improve the general agriculture of this tract. Four such crops have been tried at Quetta during the last three years—sulla (*Hedysarum coronarium*), berseem (*Trifolium alexandrianum*), annual red clover (*Trifolium pratense*) and Persian clover or *shaftal* (*Trifolium resupinatum*). Sulla is an important fodder crop of the Mediterranean region but does not withstand the cold of winter at Quetta. Berseem grows fairly well, but does not yield a satisfactory weight of produce. Annual red clover is perhaps more satisfactory than berseem, but the growth is slow although the crop is not checked by the hot weather of July. *Shaftal* proved much the most satisfactory of these plants as it will yield four crops in one year, three of which can be utilized for fodder and the last either for seed or as green-manure. The plants set seed freely during the month of June so that there is no difficulty with regard to a fresh supply for sowing. No pests have been observed on this crop when properly grown and when regularly cut. If, however, it is overwatered and if it is not cut in time, the leaves are often attacked by a rust fungus, but this does not reappear on the foliage of the new growth unless it becomes over-ripe.

II. The Cultivation of Persian Clover.

Provided a few simple precautions are taken in establishing the crop, the cultivation of *shaftal* presents no difficulties. The procedure follows, in the main, that which is usually adopted in the case of lucerne.

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[1] See "Soil Ventilation," *Bulletin 52, Agricultural Research Institute, Pusa,* 1915.

Sowing. Grown under field conditions, where the young crop is exposed to drying winds, the seedlings are most easily established under a somewhat thin cover-crop of maize or *juar*. The cover-crop protects the soil from wind and sun and also allows the *shaftal* seedlings to develop quickly a strong root-system. The amount of seed required is about ten seers to the acre and, before sowing, it is an advantage to sprout it. This is done by soaking the seed in water for a few hours and then spreading it on a damp gunny bag, in a layer about half an inch thick, and covering with another damp sack. In from six to eight hours in an ordinary room, sprouting takes place and almost all the seeds just begin to show the radicle (young root). The germinating seed should then be mixed with its own weight of dry earth (to separate it for sowing) and be sown broadcast *on the irrigation water* in the *kiaris* as soon as the water is at rest. In this manner, the seeds root at once and, on the second day, germination is complete and the soil is covered with rapidly developing seedlings. A light covering of dry earth, applied as soon as possible after sowing, does much to assist the seedlings and to conserve the moisture. A second light watering should be given as soon as the surface of the ground has dried and the seedlings cease to grow. The time of sowing is important. *Shaftal* does not germinate well at Quetta until the summer temperature falls during the second half of August. Late sowings, on the other hand, do not do well on account of the cold. It is best to sow the crop during the latter part of August and to take the first cut towards the end of October or early in November. In this way, *shaftal* develops a strong root-system before the cold weather and is able to withstand the frosts of winter without damage.

Irrigation. To obtain the best yield the crop must not be over-watered. After the removal of the cover crop in early September, a good deal of water can be saved by the use of a thin earth-mulch as soon as the irrigated surface is dry enough. The earth-mulch materially assists the young crop in establishing itself and is particularly useful when *shaftal* is sown in gardens without a cover crop. As in lucerne, the need of irrigation water is shown

by the change in colour of the foliage. As soon as the leaves begin to darken and the plants appear to contract so that the ground can be seen, water should be applied. During the winter, little growth takes place and the need of irrigation water is not great until rapid growth begins in the spring.

Yield. In considering the question of yield, it must be remembered that the duration of the crop is limited by the advent of the hot weather in June when *shaftal* flowers and forms seed. To obtain the maximum amount of fodder, the crop must be cut as soon as possible in the spring and as often as possible. A well-established and well-managed crop will yield three cuts of produce in the spring before it flowers at the end of May when the last growth can be used either for seed or for green-manure. Any delay in cutting tends to bring on rust and also weakens the stand. The total green crop yielded by *shaftal* on unmanured land amounts to about 60,000 pounds per acre per annum, but it is probable that on land in really good condition more than three crops and a greater weight of produce might be obtained.

Feeding value. Green *shaftal* is most suitable as a food for dairy cows and buffaloes, but it can be used for horses, mules or work cattle, provided it is chopped small and mixed with sufficient *bhusa*. If fed by itself in large quantities to these animals, it is apt to cause swelling, particularly in the spring when green fodder is scarce and animals are likely to over-eat themselves.

For some years, the *shaftal* grown at the Fruit Experiment Station has been sold to the Government Military Dairy at Quetta where it is considered the best fodder available in the district. As it yields a cut in the autumn after the lucerne crop is over and comes in again in the early spring, the clover crop extends the period during which green fodder is available.

Effect on the soil. The chief value of this crop in the Quetta valley is its beneficial effect on the soil in increasing its porosity and water-holding capacity and in improving the tilth. *Shaftal* forms a strong tap root which gives off a very extensive set of fine laterals. These penetrate the ground in all directions and so break up the surface soil. After a *shaftal* crop, the tilth improves and the soil assumes

that elasticity to the foot which is so characteristic of arable land in really good heart. If the last crop is ploughed in, the amount of organic matter added is of course greater and the benefit to the soil is increased. In fruit growing at Quetta, the growth of *shaftal* between the trees during the first two or three years not only brings in a good revenue but also leaves the soil in excellent condition for the production of large crops of well-ripened fruit. Such improved soils need no manure for some years and their condition, as regards tilth and fertility, is even better than that of the heavily manured fields near the Cantonments.

Seed supply. About fifteen maunds of *shaftal* seed are produced every year at the Fruit Experiment Station for general distribution. The growers of this fodder should, however, as far as possible, keep a portion of their crop for seed as the demand is increasing rapidly.

III. Clover Hay.

The advantage of good hay in the feeding of horses and mules, engaged in heavy transport, is well known. In India, real hay is however rare and its place is taken by substances such as *bhusa*, dried grass or dried lucerne, which are exceedingly hard and brittle and which have not undergone the mild fermentation processes involved in the preparation of grass or clover hay.

In 1914, at the suggestion of the Hon. Sir Henry MacMahon, G.C.V.O., Foreign Secretary to the Government of India, experiments on the drying of *shaftal* were commenced with the object of producing a fodder suitable for army purposes. If this crop is to be taken up on the large scale by the zamindars, particularly in the outlying tracts at a distance from the Cantonments, it is clear that some method of disposing of it to advantage must be devised. The demand for fresh *shaftal* is limited as, apart from dairy cows and buffaloes, it is not likely to displace lucerne as a green fodder for general use. On the other hand, it appeared likely that *shaftal* could be made into good hay more easily than lucerne.

The difficulties in making good hay in an arid climate like that of the Quetta valley are considerable. The extreme dryness of the air, combined with the effects of the sun and wind, dry any

green fodder with great rapidity and soon render it so brittle that it cannot be handled without breaking it to powder. Such a product cannot be fermented and an operation like baling is out of the question. The people get over this difficulty, in the case of lucerne, by making it into ropes while green. These are afterwards dried in the sun and stored. The product, however, is not lucerne hay but dried lucerne. No fermentation is possible and there is naturally a great loss of leaf involved in the handling of the dried ropes. The product has the further disadvantage that it cannot easily be baled so that it can only be used locally and is not suitable for an army on active service.

The disadvantages of the extreme dryness of the climate in making clover hay can be overcome by drying the fodder in stages. After cutting, the *shaftal* is spread out to dry for a day or two when it is turned and allowed to dry for another day. When about half dry, it is collected into heaps and pressed down firmly so as to check the rate of drying. Provided the clover is put into heaps just at the right stage, fermentation soon begins and, on the second day, the fodder begins to get warm. At this point, the heaps are opened and the produce carried to the stack during which it dries considerably. Some little experience is needed in determining the stage at which to stack the fodder. If it is too dry no slow after-fermentation takes place and it becomes too brittle for baling. If, on the other hand, it is stacked too damp, overheating takes place and the final product moulds. There is naturally a considerable latitude between these two extreme conditions in which the product can be safely stacked. Some drying takes place in the stack and this must be allowed for. When properly put up, the final fermentation in the stack is somewhat rapid and the light green product changes in colour to brownish green. At the same time, the characteristic sweet smell of clover hay is developed and the fodder loses its harsh and brittle character. Two months in the stack is ample for the development of the proper colour and texture after which the hay can be baled.

The loss in weight in the process of hay-making is naturally considerable and works out between 76 and 84 per cent. according

to the stage of ripeness of the green crop. A fair average would be 20 pounds of hay to 100 pounds of green *shaftal.*

A number of bales of *shaftal* hay were prepared in 1914 and placed at the disposal of the Baluchistan Fodder Stores for use at Quetta during the past winter. Major Hislop very kindly undertook to bring the hay to the notice of the various fodder-consuming units in the Cantonments and, if possible, to get it tried in one of the batteries. This was duly carried out and a full trial of the baled *shaftal* was undertaken with the horses of the 72nd Heavy Battery, R.G.A. The Commandant, Colonel M. H. Courtenay, R.A., reported on the trials as follows (Letter dated, Amara, July 30, 1915) :—

Report on Shaftal hay at Quetta.

"Up till I left my battery (72nd Heavy Battery, R.G.A.) I used *shaftal.* I found 3 lb. *bhusa* to one of *shaftal* made an excellent chop, and the horses throve really well on it and the *shaftal* made even the shyest feeders eat *bhusa* freely. I prefer dried *shaftal* to dried lucerne and further I saved at least 25 per cent. in cost. I can strongly recommend it to any horse-owner in Quetta."

During the present year, a larger supply of baled *shaftal* has been prepared and the product is unquestionably superior to that made in 1914 and tried in the 72nd Heavy Battery. The bales have been taken over by the Baluchistan Fodder Stores and Major Hislop has kindly agreed to arrange for a further set of trials. Arrangements have been made to distribute a number of sample bales to the various units so as to make the new fodder widely known.

IV. The importance of increased Production in the Quetta Valley.

The cultivation of *shaftal* is one of the chief means by which the production of the Quetta valley and of other parts of Baluchistan can be increased. The increased cropping power of this tract is of importance from two points of view—that of the zamindars and of Government.

From the standpoint of the zamindars, the cultivation of *shaftal* would be the means of utilizing the winter rainfall to advantage and would afford a fresh source of green fodder which, without much trouble, could be made into excellent hay suitable for use in the winter and also for sale to the Army. The fertility of the land at the same time would be increased and in a short time the outlying tracts would be as productive as the land immediately surrounding Quetta. Larger crops would result and a general improvement in agriculture would ensue. The water required for the *shaftal* crop would be obtained by growing the wheat crop on one irrigation instead of the seven now usually applied.[1]

From the point of view of Government, any marked increase in production in the Quetta valley and in Baluchistan generally would mean an increase in general revenue. At the same time, the supplies of grain and fodder in the neighbourhood of Quetta would be improved and the difficulties in providing forage for the Army would largely disappear. A supply of *shaftal* hay would go far to solve many military problems as the adoption of *baled* clover instead of *bhusa* would reduce the transport trains of an army on active service to a very considerable extent. A fodder reserve of pressed *shaftal* could easily be built up at Quetta and it might even be possible to export this material to the various Cantonments in the Punjab.

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[1] See the article on "The Sowing of Irrigation Water in Wheat Growing," *Agricultural Journal of India*, Vol. XI, Part I, 1916.

SOME SUGARCANE EXPERIMENTS IN TRAVANCORE.

BY

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Travancore is not a large sugarcane growing country. Out of a total area of about 1,942,800 acres under cultivation in Travancore, sugarcane is grown only in about 10,000 acres which lie mostly by the sides of large rivers. Such lands are subject to floods during the monsoons and receive therefrom a large deposit of silt which naturally adds to their fertility. Within recent years the hills of Travancore have been explored by European planters and mostly converted into rubber and tea estates. The extension of cultivation into the hills has, as a matter of course, diminished the quantity of silt which the rivers carry down; and consequently the lands by the sides of the rivers have deteriorated, and the yield of sugarcane from them has diminished to a certain extent. Under such circumstances, the only course open to sugarcane cultivators in Travancore to maintain their yield undiminished year after year is to adopt improved methods of cultivation, and particularly scientific manuring, of their cane crop.

With a view to find out the lines of improvements best suited to the country under the conditions prevailing here, a series of experiments was carried out in one of the important sugarcane centres during the cultivation season of 1914-15. A short account of these experiments and of the interesting and important results they have produced is given below.

The experiments were conducted with three-fold objects, namely, (1) to find out the best method of planting sets, (2) to

ascertain the advantages of thick and thin planting of sets, and (3) to demonstrate the most profitable method of manuring canes.

1. *Method of planting sets.* In Travancore the usual practice is that the land is prepared by ploughing or digging and is afterwards levelled and the sets are planted in small pits from 3 to 4 feet apart. Experiments in other parts of India have shown that a better method than this is to prepare the land by deep ploughing, convert it into ridges and furrows, and plant sets in furrows, the canes after a few weeks being earthed up so as to convert the original furrows into ridges and ridges into furrows. These two methods of planting sets were tried in two different plots of 10 cents each, both the plots receiving the same treatment in every other respect, and the result was that the plot in which sets were planted in pits yielded 600 lb. of jaggery (*gur*) and the other 672 lb. of jaggery. In other words the ridge and furrow system of planting sets yielded 720 lb. of jaggery more per acre than the pit system.

2. *Thick and thin planting of sets.* The sugarcane cultivator in Travancore usually plants 10,000 to 15,000 sets per acre. That this is more than what is actually required has been proved by several experiments carried out in other parts of India. The experiments in Travancore tell the same tale. Two plots of 10 cents each were taken up for this experiment; in one, sets were planted at the rate of 10,000 per acre, and in the other at the rate of 5,000 per acre. The former plot yielded 528 lb. of jaggery and the latter 600 lb. of jaggery. Thus by reducing the number of sets by one-half the yield of jaggery per acre increased by 720 lb.

3. *Manuring.* The only manure that is ordinarily used for sugarcane in Travancore is ashes, and that too not in sufficient quantity. With a view to demonstrate the superiority of a complete manure to simple ashes, two plots of 10 cents each were cultivated with sugarcane, one receiving 600 lb. of ashes alone, and the other a mixture consisting of 300 lb. of ashes, 180 lb. of oil-cakes, and 60 lb. of prawnskin (a kind of fish refuse). The yield from the first plot was 552 lb. of jaggery and that from the second plot 744 lb. Thus the application of the mixture resulted in a

net increase of 1,920 lb. of jaggery per acre. This increase, when calculated in money at the current market price of jaggery in Travancore, is equivalent to about Rs. 110. In this connection the cost of the manures must also be taken into consideration. It works out at Rs. 30 per acre in the case of ashes and Rs. 55 per acre in the case of the mixture.

It is interesting to note in passing that the best yield of jaggery in the above series of experiments was 744 lb. from a 10 cent plot, which is equivalent to 7,440 lb. per acre, and that this is not much behind the best yields obtained on Experimental Farms in other parts of India.

The conclusions that may be drawn from the experiments described above are the following :—

(*i*) Ridge and furrow system of planting sugarcane sets is superior to planting them in pits, which is the common practice in Travancore.

(*ii*) Thin planting of sets is better than thick planting.

(*iii*) The application of a complete manure to the sugarcane crop, such as a mixture consisting of ashes, oil-cakes, and prawnskin, is more profitable than the application of ashes alone.

NOTES.

RAT AND MOUSE PLAGUES.*—These plagues are of periodical occurrence in the Bombay Presidency and with the sole exception of the Konkan or heavy rainfall tract hardly any part of the Presidency escapes these ravages. The Deccan, in particular, has been overrun on several occasions. There are more than one species but Dr. Fairbank of the American Mission states that the three most destructive species are (1) the Indian Jerboa rat, (2) the Indian Mole rat, and (3) the large-eared field mouse. The principal rat plagues since 1874 are recorded in the Statistical Atlas of the Presidency, the worst of which occurred in 1878-80. It broke out almost immediately after the close of the monsoon in October 1878, and rapidly spread over the whole Deccan and Karnatak, December 1879 seeing it at its worst.

The crops most severely attacked were wheat, cotton, *jowar* and garden crops. The only grain saved was that which was hurriedly harvested before it was ripe. The immature bolls of cotton were destroyed. In 1879 the early crops were damaged just as badly as the late ones. Directly the grain was sown it was scratched up and eaten and this was repeated three times in many fields. After destroying the *rabi* crops the rats suddenly decreased in the month of December and by the end of March, 1880, they had disappeared as unaccountably as they had come. The plague was fostered by the religious prejudices of the people who thought that the spirits of those who had died of starvation in the previous famine were, as compensation, allowed to enter the bodies of the rats, and eat

* Taken from an article by Mr. T. F. Main in the *Poona Agricultural College Magazine* for October 1915.

the unripe grain and seedlings which were unfit for human consumption. A caste of men known as Vaddars showed wonderful skill and patience in destroying the rats by digging them out and these men earned large rewards. As the result of Government offering a reward of one rupee per 100 rat tails, in July 1879, 16 million tails were brought in, and in the Dharwar district alone a lakh of rupees were distributed in rewards on this scale. In 1892-93 another plague of rats is recorded. It originated in the same place as the great plague of 1878-80, *viz.*, the eastern talukas of Belgaum but did not attain such serious dimensions owing to the timely advent of rain and an enormous increase of red ticks which are probably one of nature's principal controlling methods for preventing an excessive increase of rats. Digging out was again found to be the most successful artificial method of dealing with the rats. In 1901-02 also rats did enormous damage in Gujarat, Khandesh and parts of the Deccan.

Explanation of rat plagues.

It may be taken for granted that a plague of rats always points to the failure of some natural controlling agency which usually acts as a check on excessive breeding. In the black soil tracts where rats are always plentiful any abnormal increase in numbers is usually checked owing to the soil swelling with the first heavy rain of the monsoon, and smothering large numbers. There was an absence of heavy rain in the monsoon of 1878 immediately before the great plague, and it was observed that those tracts which had suffered most in the famine of 1876-77 also suffered most from the rat-plague. This fact also supports the conjecture that the usual underground stores of grain, brought by the rats from the ripening crops, were reduced so greatly that this shortage of stored food drove the rats to seek food on the fallows—where they increased enormously owing to the favourable season. It must be noted, however, that a wet season does not necessarily imply an absence of rats. In 1914-15 after a heavy monsoon Khandesh crops suffered severely from rats. Apart from the indirect effect of rain the most powerful check on the natural fecundity of the rat is probably the

red tick referred to above. The snake and mongoose are also formidable enemies.

Damage caused by rats.

It is on record that in the great plague of 1878-80 only one-eighth of the early crop was saved in Sholapur district and that remissions of land revenue amounted to Rs. 88,480, while in the Poona district the harvests were reduced by three-fourths in the black soil tracts. In some parts of Khandesh the people did not harvest the wheat crop in 1914-15 as not a head of corn was left in the field. Mr. Gadgil reports that at Ner in Khandesh in the season of 1914-15 he found underground stores, measuring 4 feet by 4 feet and from 2 to 4 feet deep, containing as much as 16 lb. of ear-heads from which 10 lb. of grain were threshed. The Vaddars make a practice of digging out these stores to recover the grain and they also eat the rats. In Khandesh parties of Bhils were employed in 1914-15 to dig out the rat holes and recover the grain, a remuneration at the rate of one-third of the grain so recovered being given. During a plague of rats if cotton remains unpicked for a short time large quantities of *kapas* are pulled off the plants and conveyed into the soil fissures where the rats eat the seed.

Control.

As noted above the most successful method of dealing with rat-plagues adopted in the past was to dig out their burrows, but this is a most laborious process and various alternative methods have been tried. Concealing arsenic, barium carbonate or glass in small pieces of food has been tried but has not proved effective due—(1) partly to the fact that there is abundance of good food and hence any addition to it does not make any special appeal to the rats, and (2) the natural instinct of the rats, which undoubtedly warns them against such food after the first few deaths. The invariable experience with poisoned baits has been considerable success for a day or two followed by failure. Trapping is not practicable, the numbers being too large. The most efficient weapon which we have so far discovered for use against field rats is fumigation. At Nadia

Mr. Jhaveri who conducted the experiments happened to possess a white ant exterminator consisting of a vessel within which charcoal and sulphur are burnt and to which is attached a flexible wire tube and pump for discharging the sulphur fumes into the rat holes.

The procedure of fumigation.

In practice it is usual to find that several holes are connected one with another by run-ways in all directions, and it is necessary to stop up all bolt holes before pumping in the sulphur fumes. The machine is then worked for about three minutes. For this purpose one *tola* of sulphur powder per hole is required and about sixty to eighty holes can be fumigated in a day by a party consisting of two trained coolies at a total cost * of less than one rupee in *goradu* (sandy) soil. It was feared that fumigation would prove difficult in the black soil where large cracks extend in every direction, but it has been found possible to work it on these soils if an extra coolie be employed to assist in scraping loose soil over the cracks. In this way it was found that the sulphur fumes spread through an area varying from one-tenth to one-half *guntha* according to the length and width of the fissures and for this purpose $1\frac{1}{2}$ to 2 *tolas* of sulphur were used, the time required for such an operation varying from 5 to 7 minutes.

* Items.

Wages of two coolies at 5 annas ..	R.	0	10	0
Cost of $1\frac{1}{4}$ lb. of sulphur		0	3	0
Cost of charcoal		0	1	6
Total ...	R.	0	14	6

A white ant exterminator is a rather expensive machine, costing some sixty-eight rupees when imported, but it is hoped to get suitable machines made in the Presidency at a much lower figure.

* * *

INDIAN HYOSCYAMUS.—The great European war which has now been raging for over seventeen months has brought the world face to face with many economic problems which have previously escaped the notice of the general public. We read of the disturbance caused in the world's dye markets and the trades

depending upon artificial dyes by the isolation of Germany, and one important phase of this in Indian rural economics is that the natural Indigo trade has taken a new breath of life for the time being. Germany for the first time to the uninitiated appears in the rôle of the principal producer and controller of the world's supply of fine chemicals. Not least in importance of these are the many medicinals of which Great Britain and her dependencies now find themselves short, dangerously short. A number of these compounds belong to the class of so-called synthetic drugs—that is to say such medicines as antipyrine, sulphonal, etc., which are artificially manufactured from simpler compounds. But besides these the faculty still has to make use of a number of plant products, medicinal principles, which can be isolated only from specific plants and parts of plants like quinine from the Chinchona bark; strychnine from the *Nux vomica*; and atropine from the *Atropa belladonna.* Similar to atropine is another well known mydriatic alkaloid of wide use, *viz.*:—hyoscyamine—which is obtainable from the *Hyoscyamus niger*—the henbane of the English country lane. The writer recently had occasion to analyse a sample of Indian Hyoscyamus (probably the *Hyoscyamus muticus*—an allied species of the genus *Hyoscyamus*) grown in the Punjab where large quantities of the plant occur in the wild state along the river sides. The assay showed the dried plant to contain the very high amount of 0·827 per cent. of mydriatic alkaloids. This is very much richer than the English henbane, in fact it is nearly ten times as strong. Specimens of Indian henbane have been known to contain as much as 1·28 per cent. of alkaloid and unlike the English variety *Hyoscyamus niger* which contains the alkaloids hyoscyamine, hyoscine, and scopolamine the Indian variety *muticus* is said to contain only hyoscyamine. As a source of this important alkaloid hyoscyamine Indian Hyoscyamus should receive the attention of the manufacturer of fine chemicals and drugs.

For the information of those readers of the Journal who are interested in the chemistry of this subject or the manufacture of hyoscyamine, below are given the details of the method of assay used, which is a modification of that devised by Rupp. (*Pharm.*

Zeit. 1908, 738; *Chem. Zeit. Rep.* 1908, 32 529; *Pharm. J. Russ* 1911, 138; *J. Pharm. Chem.* 1911, 3,551). The method can be used for assaying extracts of belladonna also.

Twenty-five grams of the powdered leaf are extracted with 300 cc. hot alcohol Sp. Gr. 0·829 in a Soxhlet tube (4 times was found sufficient to exhaust the leaves and obtain a washing free from alkaloids). The alcoholic extract is evaporated until a sticky brown mass is obtained. This is weighed and the weight noted. Six grams of the extract so obtained is weighed into a stoppered flask. About 5 cc. of water, 90 grams of ether and one gram of ammonium hydrate are then added and the mixture shaken for 15 minutes. After separation 60 grams of the clear ethereal layer is filtered off and the solvent evaporated. The residue is then treated with 5 grams of ether and again evaporated to dryness. This is repeated three times, each time with 5 grams ether. The residue is then dissolved in 5 grams of alcohol 70 per cent. and the solution transferred to a graduated 100 cc. flask.

The first flask is washed out with another 5 cc. of alcohol 70 per cent. and then with water. To the bulked washings is added 20 grams of sodium chloride and 20 cc. of N/100 HCL are added with sufficient water to bring the whole contents up to 100 cc. After thorough agitation the solution is filtered. 50 cc. of the filtrate is transferred to a stoppered flask. 30 cc. of ether and 5 drops of Iodeosine indicator are added. The excess of hydrochloric acid is then determined by titration with N/100 KOH in the usual manner.

In the meantime a blank experiment *with the same reagents* but without any extract of the leaves, is performed to obtain the correcting factor for reagent impurities, and this is deducted from the above titration figure. This precaution is absolutely necessary as a correction of upwards of 2 cc. of N/100 HCL is frequently found.

Each cc. of N/100 HCL used by the alkaloids = 0·00289 of mixed alkaloids as hyoscyamine.

This is not the first time that Indian Hyoscyamus has been examined, for Dunstan and Brown examined a specimen (*J. C. S.* 1899, 75,72), but only 0·1 per cent. of alkaloid was then recorded.

It is possible that more than one variety of Hyoscyamus exist and that the alkaloidal contents of the varieties differ considerably. It is also more than likely that the amount of active principle present will depend upon the age and condition of the plant, for Godamer (*Arch. Pharm.* 1898. 28), has shown that in *Hyoscyamus muticus* the stalk contains 0·49 per cent., the leaf 0·9 per cent., and the seed capsule 0·585 per cent. of alkaloid.

Previous to the outbreak of the present war not only was a large proportion of the drug grown in Germany but German chemists practically held a monopoly for the manufacture of the alkaloid.

If then the supply of this substance falls short of the demand, English manufacturing chemists can obtain an adequate supply of the raw material from Northern India, for the plant can be exported in the dry state without impairing its value for alkaloidal manufacture.—(J. H. BARNES.)

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In view of the present cross-breeding experiments being carried on in the various dairy farms and milk centres of India with various breeds of English cattle, the 1914 Year-Book of the British Holstein Cattle Society is of great interest. It is clear from a glance that this breed is now the foremost of its type, a type which is undoubtedly the most useful for all-round purposes.

It gives an enormous quantity of milk with an average yield of 3·30 per cent. of fat. This, while low in comparison with the Jersey's 5·13 per cent. and the Guernsey's 4·87 per cent. when taken in comparison with the average milk yield per day of the three breeds, works out strongly in favour of the Holstein which gives 48·9 lb. of milk per day to the Guernsey's 28·9 and the Jersey's 24·5, while the Ayrshire whips in with 3·85 per cent. of fat and a daily yield of 27·7 lb.

These figures total up to an *average daily fat yield* of

lb. 1·61 from the Holstein,
,, 1·41 from the Guernsey,
,, 1·26 from the Jersey,
,, 1·07 from the Ayrshire,

which points to the undoubted fact that the Holstein can hold its own with any breed over an entire day's average, although the fat content is undoubtedly lower in any given sample of milk taken from it; for when one compares a 600-gallon cow giving 5 per cent. fat with a 900-gallon Holstein giving only 3·5 per cent., you get a balance of fat in favour of the Holstein over a year's working of some 15 lb.

The fat globules of Holstein milk are very small and the milk is naturally easy of assimilation. It is therefore especially suitable for the feeding of infants. This fact is very well appreciated in the United States of America.

The Holstein is a large, vigorous animal, yet docile and gentle. She is a real genuine ranger and will pick up a living anywhere, while her constitution is thoroughly sound and her calves hardy and strong. She also breeds to a good old age and milks freely to the end, while when dried off she fattens up rapidly, being devoid of that curious inability to fatten which is characteristic of so many milk breeds. It would therefore seem that in this country where the cow that gives very little milk with a high percentage of fat is all too common an out-cross with this vigorous breed is bound to do much good, for the size of the Holstein and great breadth and strength compared with the angularity shown by the usual milk breed should make the bull-calves grow into excellent draught animals and it is obvious that the milch stock with such enormous records behind them, 1,000-gallon cows being quite common now, cannot fail to become milk producers of the first class, as in the whole breed there is ingrained a hardiness of constitution unimpaired by any extensive in-breeding for Show Yard purposes which undoubtedly undermines and brings to a speedy close the careers of so many first class bulls out here.

This breed is descended from Friesian cattle, one of the several groups of Dutch cattle imported into England. It may be mentioned that Dutch cattle have been instrumental in the development of the dairy herds in many countries and prosper even in the Arctic regions of Russia. They are most famous in America where the importation of pure bred cattle has been considerable. In

South Africa these cattle are very widely distributed over the Cape and Free State Provinces and over the Transvaal. New Zealand and Japan are now importing great numbers of Friesian cattle, and taking into consideration the number of different climates they have proved a success in and the diseases they have been proof or almost proof against, no greater testimony can be paid to their universal hardiness and suitability for all countries.

It would seem therefore, that we should give an extended and careful trial to this extraordinarily useful breed, which may have the power of benefiting our dairy work to a considerable extent.—(WYNNE SAYER.)

REVIEWS.

The Score Card System of Dairy Farm Inspection.—Published by the National Clean Milk Society, 2, Soho Square, London. Price 6*d*.

This pamphlet is based on the American method of controlling dairy inspection by means of score cards enabling the Government to see at a glance in which particular the dairies of the country fail and what steps can be taken to improve the methods at present in vogue—and where legislation will have a beneficial effect in maintaining the purity of the milk. The score card for the inspection of dairy farms is designed to direct attention to all the essential details in the production of clean milk and indicates from the proportion of marks allotted the relative importance of each item in relation to the conditions as a whole. It sets up an ideal standard for a producer of milk. The division of the card into columns for equipment and for methods enables a farmer to realize more clearly whether the improvement of any condition is within his power or not. In the United States of America the system is not confined to the inspection of farm dairies but different score cards are also used for wholesale milk dealers' premises and for retail milk shops.

This system of inspection will be appreciated more and more as people realize that the cleanliness of milk is of greater value from the point of view of health than its chemical composition and that this cleanliness is promoted by the production and handling of milk under sanitary conditions.

At a first glance it would seem that the card aims at an impossible perfection—at least for India—but there is little doubt that any Indian dairy which could get 10 marks out of the possible 100 would be a phenomenon. It would seem that the

health of cows and cleanliness of utensils and attendants are the places where an attempt ought to be made to at least colourably imitate the millennium advocated in the pamphlet. It is obviously not going to be easy to have the well drained and well situated cowsheds advocated, and it would seem best to do all that can reasonably be accomplished with the material in hand, and after all to get milk from a healthy cow drawn by a clean pair of hands into a clean utensil is making a very great advance on the conditions which are all too prevalent nowadays. It is when the milk and dairy industry becomes properly organized that we shall get properly built and properly drained cowsheds which will be a natural adjunct to a large and properly conducted milk business. At present the best we can do as regards buildings is to collect the *gaolis* of any particular town and put them up a building under the co-operative scheme where they can be controlled ; any individual effort would be doomed to failure. There is, however, in the pamphlet an interesting paragraph on the small top milk pail to which on the score card what may seem an unduly high percentage of points is given. But on examining the results of tests it is seen that no single improvement has produced such a beneficial effect on milk cleanliness. It is here in the purchase and use of such utensils that much can be done towards attaining a moderate standard of cleanliness which will, it is hoped, be the forerunner of an era of cleanliness which must supersede the present methods of the *gaoli* if the health of the country is going to improve, for it is difficult to imagine a greater danger to the infant life of India than the present state of dirt and dishonesty which seems inseparable from milk and its purveyors.—(W. S.)

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CONTENTS

THE NINTH MEETING OF THE BOARD OF AGRICULTURE IN INDIA.

The Ninth Meeting of the Board of Agriculture was held at Pusa from 7th to 12th February 1916, under the presidency of Mr. Bernard Coventry, C.I.E., Agricultural Adviser to the Government of India. Before proceeding to a consideration of the subjects discussed at this meeting it would not perhaps be out of place to mention the difference in the functions of the Board of Agriculture as constituted for India and the similar body in Great Britain. The duties of the Indian Board are purely advisory, while the English Board has administrative functions and is therefore working continuously. The Board of Agriculture in India meets every two years, alternately at Pusa and in one of the provinces. Thus the eighth meeting was held at Coimbatore towards the close of the year 1913.

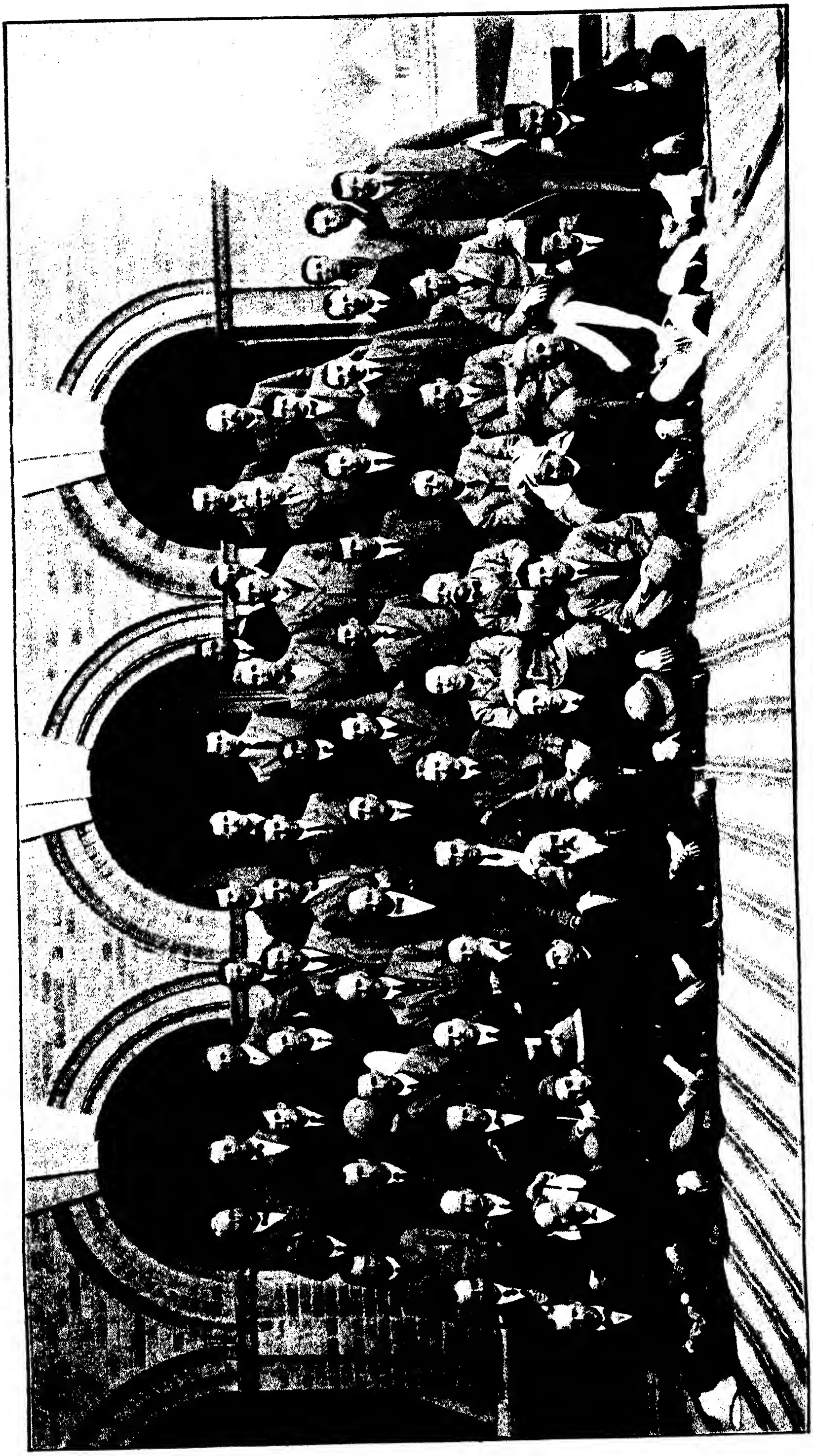
The advantages of such an institution cannot be overrated. It brings together most of the scientific workers engaged in the provinces and thereby gives them the opportunity of comparing notes, exchanging ideas, and seeing that their work does not overlap. It also places before the public a vast mass of useful information and experience gained regarding the subjects brought forward for discussion. And as some of the subjects are of economic importance the notes and discussions thereon have a value all their own.

The meeting at Pusa was attended by 47 members and 24 visitors. Among the visitors may be specially mentioned the Hon'ble Mr. C. H. A. Hill, C.S.I., C.I.E., I.C.S., Member in Council, in charge of the Department of Revenue and Agriculture of the Government of India, Mr. James Mackenna, I.C.S., Col. Hallowes, Director of Military Dairy Farms, The Hon'ble Mr. Morshead, Commissioner, Tirhut Division, Mr. H. M. Lefroy, Imperial Silk

Specialist, Messrs. Collins and Crosthwaite, Registrars of Co-operative Societies, Central Provinces and Bihar and Orissa. Mr. Wynne Sayer, Assistant to the Agricultural Adviser to the Government of India acted as Secretary. Great interest was evinced in the deliberations concerning the closer connection between the Agricultural and Co-operative Departments, Cattle-breeding and Dairying and Soil Denudation by rainfall and drainage, and important practical conclusions were reached on the subjects.

The Hon'ble Mr. C. H. A. Hill opened the proceedings with a short speech in which he eulogized the services of Mr. Coventry and referring to the subjects for discussion he said that one of the most interesting from the point of view of the wider development of improved agricultural methods, is subject VIII relating to the connection between co-operative movement and agriculture. He hoped that the remarks, of the Committee on Co-operation in India, in paragraphs 198-200 of their report would be of considerable help in the deliberations of the Board and said that a basis upon which the work of the agricultural and co-operative movements can be co-ordinated is required to be arrived at. Different methods may be required for different provinces and their working out may take time. But that need not delay the bringing about of unified action between the agricultural employés and the Co-operative Committees throughout India. He urged upon the Board to bear in mind throughout their discussions that it matters far less what means are employed to bring about co-operation than to secure that such co-operation is brought about. He then proceeded to refer to the question of cattle-breeding and dairying in India. He dwelt upon the advisability of taking long views in all questions connected with the development of Indian agriculture and emphasized that 'it is only through the creation of a body of Indian agriculturists throughout the country, who shall not only be qualified to till the soil efficiently and economically, but who shall have developed a spirit of inquiry and an intelligent desire to keep abreast of the times, that we shall really achieve the results which we aspire to.' The President then addressed the meeting and after gratefully acknowledging the kind references

PLATE II.



BOARD OF AGRICULTURE. 1916

to his work by the Hon'ble Mr. Hill referred to the sad death of Lt.-Col. J. D. E. Holmes and paid a tribute to his work as Imperial Bacteriologist. He then briefly related the principal changes that had taken place in the Agricultural and Veterinary Departments during the last two years and the action taken on the resolutions passed at the last meeting of the Board. He then took a short review of the principal subjects down for discussion.

There were 13 subjects for discussion. Subject I was the confirmation of the Proceedings of the last meeting. This being done committees were appointed to deal with the remaining subjects.

SUBJECTS II AND III. *Programmes of work of (a) the Imperial Department of Agriculture, (b) the Imperial Bacteriologist, Muktesar, (c) the Provincial Agricultural and Veterinary Departments, (d) Native States' Departments of Agriculture.*—Space does not permit us to enter into details of elaborate programmes submitted for the approval of the Board. These programmes were confirmed with slight additions and alterations. With regard to the submission of the programmes for the approval of the Board considerable discussion took place. It was pointed out that the programmes even when approved by the Board could be departed from, that they did not show in some cases, *e.g.*, in that of Mycology what work was to be done and that the reports of the Committees appointed to consider the programmes were generally of very little use. For any information regarding the stage at which a particular investigation has arrived or as to who is working on a particular subject the Annual Reports of the Pusa Research Institute and the Provincial Agricultural and Veterinary Departments which are usually published a few months before the meeting of the Board of Agriculture, might be consulted. It was therefore suggested that the present practice of submitting the programmes to a Committee should be dropped. Several other suggestions were put forward, and it was ultimately resolved that " it be recommended to the Government of India that the submission of programmes both Imperial and Provincial to the Board may be definitely dropped." The Committee appointed to consider the programmes of Provincial and Native States' Departments of Agriculture referred

to the difficulty of examining programmes without sufficient notice and suggested that the names of members whom it is proposed to invite to serve on committees should be circulated some time in advance of the meeting. Mr. Wood therefore suggested that a list of subjects for the Board's discussion should be circulated to all Directors of Agriculture and moved a resolution that "the Board recommends that the Directors of Agriculture should be asked to state on which Committees they prefer their men to serve and that the Agricultural Adviser to the Government of India should therefrom appoint Provisional Committees, as long as possible before the Board meets and communicate them to the Provinces." This resolution was accepted by the Board.

With regard to the programme of work of the Imperial Bacteriologist, it was suggested that if possible, an inquiry should be made into the vitality of the rinderpest virus outside the body under varying conditions. The point is of importance to cattle insurance societies and to cattle-owners generally to determine the period within which it would be safe to replace cattle after an outbreak of disease. This recommendation was accepted by Mr. Shilston and the programme was approved.

Some of the programmes of Provincial Veterinary Departments appeared to the Committee to be unduly ambitious having regard to the strength of the superior staff, and it seemed to them that more was being undertaken than could be effectively carried out without an increase of the supervising staff. This applied particularly to the Provinces with a single Superintendent. The extent to which practical effect can be given to much of the work of the Muktesar Laboratory depends on the number of trained men available in the Provinces for carrying out inoculations but practically all Provincial Departments are below their proper strength. For the furtherance of research work the Committee thought co-operative action between the Muktesar staff and Provincial Superintendents very desirable and this can only be ensured by the strengthening of both the Imperial and Provincial staffs. The report of the Committee was accepted by the Board.

SUBJECT IV. *The Policy to be adopted in regard to the supply of cattle to foreign countries.*—Very little information of value can be gathered from the figures relating to the export of animals from the various Indian ports, since these figures do not distinguish between cattle, sheep and goats but are given for all animals excluding horses, they do not distinguish between animals of good breeds and animals which are of little value except for purposes of slaughter, nor do they indicate clearly the part of India from which the cattle are drawn. It is understood that considerable numbers of inferior cattle are exported from the Madras ports to Ceylon for purposes of slaughter and this is in every way advantageous to stock-owners. A fair number of miscellaneous draught and milch cattle are also sent to Ceylon, the Straits, and Burma for draught and milk purposes, but there is no reason to object to this. The difficulty of regulating the export of valuable breeds would be considerable. As regards the necessity for regulating the export with a view to prevent a serious depletion of the best breeds, the only breeds for which there is any evidence that they are exported on a large scale are the Kankreji breed from North Gujerat and the adjoining Native States (Bombay), the Karachi breed and the Ongole breed of Madras. Of these the latter two have suffered more or less and while this is attributed mostly to export of cattle to foreign countries another factor in the depletion consists of the fact that Karachi cows have been purchased largely by the military and other dairies which take them to distant parts of India where many of their offspring get merged in the local breeds and that numbers of good Ongole cows are taken to Madras by dairymen and are there slaughtered after their period of lactation is at an end. The export of cattle is to the profit of the breeders in the long run. The Board was therefore not in favour of putting any restrictions on the export of cattle that are in demand abroad but recommended the maintenance, in the middle of breeding tracts, of pure herds of such cattle and the assisting of the breeders in every suitable way to extend and improve their present operations.

SUBJECT V. *The Nomenclature of certain posts in the Imperial and Provincial Departments of Agriculture.*—There does not exist

at present any uniformity in the designation of officers of the Imperial and Provincial Agricultural Services in different provinces discharging the same duties and having the same emoluments, *e.g.*, the designation of Assistant Director is given to a member of the Provincial Service in one province while in another it is reserved for the junior members of the Indian Agricultural Service. In the Provincial Service various designations are used to denote more or less the same duties, such as Assistant Director, Divisional Inspector, Extra Assistant Director, Agricultural Supervisor, Travelling Inspector and the like. The points for consideration were: (1) whether the designations are uniform in different provinces and whether they correctly indicate the work on which the officers are employed; (2) whether they indicate any relations between the Imperial and Provincial Services; and (3) if no leave reserve is provided in the Imperial Service, whether the Board can recommend a nomenclature which would express the intention of Government to give opportunities to members of the Provincial Service to act in leave vacancies and thereby prove their fitness for permanent promotions. The principal recommendations of the Committee which were adopted by the Board were: (*a*) That Deputy Directors be designated by circles rather than by serial numbers indicative of seniority in the service. The designation of Assistant Director should be reserved for junior officers of the Indian Agricultural Service until they are confirmed in charge of circles. (*b*) There should be no distinction in the Imperial and Provincial Services of officers performing the same duties. (*c*) In order to make the status of experts more clear the words "to Government" and "the name of the Presidency or Province" be added to the designation. (*d*) The executive officers of the Provincial Service be designated Divisional Superintendents of Agriculture in all provinces. With reference to (3) the Committee had no recommendations to make to that end. They believed that their other recommendations would dissipate all confusion.

SUBJECT VI. *Soil denudation by rainfall and drainage: Conservation of soil moisture.*—This subject is of special importance. A large amount of surface soil is washed away every year by rain

from the monsoon-fed tracts which impair the fertility of the soil. The damage done to the soil by surface washing in the past is so enormous that it cannot be removed by any system of manuring. It is therefore imperative to take measures to prevent further damage. This subject was brought up for consideration at the meeting held at Coimbatore, but the information then on hand was too meagre for the Board to make any recommendations.

Dr. G. D. Hope, Scientific Officer to the Indian Tea Association, submitted a note describing the elaborate system of terracing and drainage adopted on Java Tea Estates for controlling the rain wash. This note is printed separately as an article in this issue. The Committee agreed with Dr. Hope as to the general adaptability of these methods to conditions in Assam and elsewhere.

The losses due to soil erosion are to a great extent preventable and in the case of planting areas the Board recommended that the Government of India be asked to bring to the notice of the planters, through the medium of the Indian Tea Association, United Planters' Association of Southern India, District Officers, and other channels that effective measures should be taken to prevent soil erosion on the existing areas and when new areas are opened. They also suggested that Local Governments should safeguard against this danger of erosion when fixing the conditions on which new lands are given out.

In Peninsular India the question of preventing soil erosion has already been taken in hand in Bombay. Preliminary enquiries are complete, and the Director of Agriculture has formulated definite proposals to begin the work on an organized line. To carry out this work the Board recommended that the Government of India should be requested to place at the disposal of the Bombay Department for a period of five years an engineer with experience and aptitude for agricultural work. The sole duties of this officer should consist in the preparation and execution of schemes of embankment and drainage adapted to local conditions.

As regards the alluvial tracts of Northern India, the "Pusa" system of surface drainage is found to materially increase the cropping power of the land. For an efficient application of this method it is essential that the natural drainage systems of these tracts should be closely studied. In North Bihar the natural drainage has been so interfered with that the high flood level is rising at the rate of several inches a year and thereby doing an increasing amount of injury to crops. The Commissioner of Tirhoot has taken in hand the question of improvement of the drainage in North Bihar with a view to preventing as far as possible the recurrence of floods. The Board welcomed this attempt.

In connection with the subject of conservation of moisture the Committee felt that while the advantages of interculture and of surface cultivation generally are well known in many parts of India and attention is being paid to it by the Agricultural Department a great deal remains to be done both to improve the best indigenous practices and also to introduee these methods into new localities. The results obtained at Quetta indicated that for every hundred acres of irrigated land the water lost every year would produce wheat and *bhusa* worth Rs. 50,000. The Board expressed their opinion that any experiments having for their object the discovery of the most economical and efficient use of irrigation water should be encouraged and developed by the Agricultural Department.

SUBJECT VII. *How the energies of the Veterinary Department can best be utilized in the control and check of cattle diseases and what means should be adopted for increasing the numbers of the subordinate staff as recommended at the last meeting of the Board.*—This subject was also discussed at the last meeting. For the control and check of cattle diseases it is essential for the staff of the Veterinary Department, both superior and subordinate, to gain the confidence of the villagers and be in closest possible touch with them and the local district officers. But in most of the provinces the Departments are understaffed in all grades. Schemes for the expansion of the subordinate staff have, however, either been sanctioned or are in contemplation in most provinces. But the

difficulty in obtaining trained men is causing delay in carrying through the schemes where sanctioned. This is especially the case in the United Provinces and Bihar and this difficulty is not likely to be satisfactorily removed until funds permit the construction of the proposed Veterinary College in the United Provinces to serve the needs of that province and of the Hindi-speaking portion of Bihar. In connection with the inoculation work and the class of men by whom it is to be done the opinion of the Committee was that generally it is most undesirable to employ any but well-trained men in any of the ranks of service whenever such men are to be placed in positions of semi-independence. The Committee recommended that the subordinate staff should be under the control of the Veterinary Department. It also suggested the increase of the superior staff before a large subordinate staff is recruited in order to ensure adequate supervision, drive and general control. The report of the Committee was accepted by the Board.

SUBJECT VIII. *The Co-operative movement in its relation to agriculture. How to organize the relations between the Co-operative Societies, whether dealing with credit or some other branch of agricultural organization; and the Agricultural Departments? Whether there is any need to encourage Agricultural Associations in view of the special facilities possessed by Co-operative Societies for carrying on propaganda.*—This was one of the important subjects before the Board. It was considered by a strong Committee including two Registrars of Co-operative Societies which made ten recommendations and these with slight modifications in some cases were passed as resolutions.

(1) Agricultural Associations perform useful functions where a central co-operative association either does not exist or is not fully developed and even where such associations do exist there is no need to discourage Agricultural Associations when the members really undertake pioneer work. But when central co-operative associations are fully developed the Agricultural Department should use them first and foremost as a means for demonstration and introduction of improvements and should concentrate its attention on them. This view of the Committee was accepted by the Board.

(2) The next question was with regard to the finance of Central Banks: whether it is desirable that separate capital should be set aside for agricultural improvements which should be distinctive from the banking capital. It was pointed out that a Central Bank would involve itself in difficulties if it were to start trading on a large scale. The Board agreed with the view of the Committee that the working capital of the bank should not be employed in commercial enterprises. For the distribution of seeds, implements, and other similar activities the bank should either act as an agent or raise separate capital or make allotments out of profits or reserves. The agency system has been found to work satisfactorily in the Central Provinces. But a form of Central Association with separate share capital in which societies or individuals would become shareholders might well be developed. All dealings of this kind should be for cash only and members must, if necessary, borrow from their credit societies for these purposes.

(3) It was resolved that where credit societies exist in any village they must be utilized for getting orders for seed, etc., but as societies they should not engage in trade but only give loans to their members to make purchases. Agreements to purchase should be taken from individuals before orders are given. Where no credit societies exist co-operative associations, such as those working in the Northern Circle of the Central Provinces, might be found useful. The Board resolved that unregistered co-operative associations for the supply of pure seed, etc., should be discouraged.

(4 and 5) In connection with the steps to be taken to bring the officers of the Agricultural and Co-operative Departments into closer touch, etc., the Board resolved that this could be done by making the staff of the Agricultural Department familiar with the principles of co-operation and by giving to the staff of the Central Bank such practical training in agriculture as may be necessary and possible. The other step considered necessary for this purpose was that, in addition to Agricultural Inspectors and Assistants who are to be appointed in each district, a Government official who should be subordinate to the Deputy Director and

the Agricultural Inspectors or Assistants, should be attached to each Central Bank which is sufficiently developed. Such a man should be a practical cultivator who can read and write.

(6 and 7) The Board resolved that Government should bear the cost of all demonstration work in each area, and for this purpose they should find the money. It was also resolved that in places in which the Agricultural Department propose to open demonstration farms in tracts in which there are also well developed Central Banks one at least should be started at the head-quarters of such banks at the expense of Government.

(8) As regards cattle insurance the opinion of the Board was that it is unsafe unless adequate arrangements are made for dealing with outbreaks of epidemic diseases and that the fixation of tariffs depends on local conditions based on more satisfactory actuarial data than those available at present.

(9 and 10) The proposals for the Development Commissioner made by the Committee on Co-operation in India did not commend themselves to the Board. While the Board desires to emphasize the necessity of adequate programmes of general development and of the regular allotment of funds it considers that in respect of the Co-operative movement and of the Agricultural Departments these proposals are unsuitable. It appears from the report that the officer appointed to this post would be mainly selected on account of his qualifications as a co-operative organizer, which means the appointment of a non-technical officer at the head of the Agricultural Department. Again, where the Director of Agriculture and the Registrar are directly under Government it would involve extra delay and loss of efficiency if another officer is appointed between them and Government. The real improvement in the opinion of the Board lies in placing these officers under the direct control of Government in the provinces where they are at present under a Financial Commissioner or Board of Revenue. The necessity of a closer connection between the Co-operative and Agricultural Departments was, however, recognized, and the Board recommended that co-ordination should be secured by the formation of a Board consisting of the Registrar, the Director of Agriculture and the

Director of Industries where he exists, which would meet from time to time and make their joint representations to Government when necessary. It was further resolved that it would be a good thing if some at least of the Directors of Agriculture could attend the Imperial Conference of Registrars.

SUBJECT IX. *To what extent forest tracts act as harbours of rinderpest during the rainy season and what steps can be taken to combat the condition.*—In some provinces serious outbreaks of rinderpest do synchronize with the return of the cattle from the forests and hills to the plains, but the Committee was unable to make any recommendations on the subject on account of lack of any direct evidence as to the relative importance of this question, the impossibility for economic reasons of closing such common grazing in forests, the difficulties in carrying out effective inoculations in such remote tracts, and the shortage of the staff in the Veterinary Department.

SUBJECT X. *Indian Sugar Industry.*—This subject was fully discussed at the last two meetings. The Committee drew out a detailed report showing the progress made in different provinces. In connection with the small plant installed at Nawabgunj under Mr. Hulme's supervision the Board regretted that sufficient steps were apparently not taken to ensure a proper supply of cane to the factory during the last two years to give the experiment a fair chance of success. The Board could only recommend the continuance of the experiment if the United Provinces Government could undertake to obtain for the factory a sufficient amount of cane locally to keep it working at optimum conditions whether by giving advances to the cultivators to grow cane or otherwise. A balance sheet showing the results of the experiment was considered to be essential in framing a judgment as to its value.

It was noted with regret that the sugarcane station recommended by the Board in 1911 for North Bihar had not yet materialized. In view of the fact that this tract has so far proved itself one of the most promising fields in India for the production of white sugar on a manufacturing scale and for the establishment of the central factory system on a sound commercial basis, a sugarcane

station is of prime importance for the proper maintenance of the industry and should be started as soon as possible. And in view of the difficulties that appear to have prevented the establishment of such a cane station hitherto, the Board recommended that the interests of the sugarcane cultivation in North Bihar should be definitely committed to the charge of an officer of the Agricultural Service.

Other resolutions passed by the Board were regarding (1) the continuation of the Kamrup Experimental Sugarcane Farm in Assam, till it has been sufficiently shown whether sugarcane can or cannot be grown in that tract on large scale at a profit, and (2) the continuation of the cane-breeding station at Coimbatore in Madras, which has already done much valuable work in connection with the raising of seedlings, under general financial and administrative arrangements similar to those which have hitherto prevailed.

SUBJECT XI. *Cattle Breeding and Dairying in India.*—This subject was also considered at the last meeting of the Board. A memorandum on the scheme for cattle-breeding and dairying in India prepared by the Agricultural Adviser formed the basis of discussion on the subject. The Committee considered the scheme in detail and submitted the report on the basis of which the Board resolved that in order to make satisfactory progress in the development of good breeds of milch cattle in India and in dairying an officer should be appointed on the Imperial staff under the title of Imperial Dairy Expert, his duties being (1) the control of the cattle-breeding farms and dairy operations contemplated in the scheme; (2) the supervision of dairy instruction; (3) the study and improvement of existing dairy methods in the country and the establishment of the industry on a commerical basis. He would generally advise and assist Local Governments, Provincial Officers, and Military Dairy Farms. The Board also considered that the arrangements proposed and the estimate prepared by the Committee were reasonable and the officer when once appointed should not be liable to transfer. It was resolved that in the opinion of the Board the offer by the military authorities of the herds of various breeds of pure bred Indian cows and buffaloes as

well as the facilities for conducting further breeding operations on the military dairy farms is of extreme value and should be gladly accepted. Advantage should be taken of this offer as soon as the Imperial Dairy Expert is appointed. The appointment of a Chemist was recommended at least for a period of 10 years to investigate the problems regarding the food values and the digestive capacity of Indian farm animals. Other principal resolutions were with regard to the establishment of the dairy schools to fill the need for trained dairy managers, arrangement for immunization of cattle against disease by increasing the Muktesar staff, the advisability of instituting an investigation into the existing supply and demand for dairy produce on the lines of the inquiry made by the Bombay Department before any fixed policy is adopted in any province for the encouragement of the dairy industry, and lastly, the legislation against adulteration in dairy produce. The Board reaffirmed the resolution passed at Coimbatore in 1913 with regard to the conditions for the improvement of cattle in India (p. 16 of the Proceedings) and desired to lay special stress on points 3 and 9 in the report of the Committee then adopted.

SUBJECT XII. *The best agency for controlling cattle-breeding.*—The question for consideration was which of the two Departments, Agricultural or Veterinary, is the better agency for controlling cattle-breeding. Cattle-breeding is a distinct business apart from both agricultural and veterinary work, and requires special qualifications. The officer appointed to deal with this business should devote his whole attention to it. It is also very desirable that he should remain on the job all his service so as to attain optimum results. The Committee considered that in the existing cattle-breeding organization in India it would be unfortunate if either of these two Departments were entirely disconnected with cattle-breeding or wtih the wider questions comprised in the term "animal husbandry." In connection with animal husbandry the problems appear to differ in different provinces and the organization has developed on different lines. It was therefore considered that it would be best for the various provinces to arrange for the control of animal husbandry with reference to the particular problems involved

and the nature of the agricultural and veterinary organization that may be in existence or contemplated. This was accepted by the Board.

SUBJECT XIII. *Fisheries.*—The question for consideration was whether the subject of fisheries should be dealt with by the Board of Agriculture and whether the Fishery Experts of Bengal, Bihar and Orissa, Madras, and the Punjab should be made permanent members of the Board. Excepting Bengal and Bihar and Orissa, the Fishery Department in other Provinces is separate from Agriculture and even in Bengal, Bihar and Orissa it is connected with the Agricultural Department by accident. The Board therefore decided the question in the negative.

This brought the consideration of subjects on the agenda paper to a close when Mr. Keatinge invited the Board to hold their next meeting at Poona. This offer was accepted subject to the approval of the Government of India. Before dispersing thanks were voted to the President who was shortly retiring from the post of Agricultural Adviser to the Government of India, to Mr. Dobbs for successful work as Secretary during the two previous meetings of the Board and to Rao Saheb Nagarji, Superintendent, Office of the Agricultural Adviser to the Government of India, for his valuable services in connection with the meetings of the Board.

CATTLE INSURANCE SOCIETIES.*

BY

A. C. CHATTERJEE, B.A., I.C.S.,

Registrar, Co-operative Societies, United Provinces.

THE predominating object for loans in our agricultural primary societies is the purchase of plough or draught cattle. A perusal of the status or *haisiyat* registers shows that plough cattle comprise the chief movable property of members. As is well known, houses and buildings in rural localities would fetch very little if sold and the tenant right of occupancy or non-occupancy tenants or of statutory tenants in Oudh cannot be alienated. It is very important therefore from the point of view of the societies as well as of the members to devise means, whereby the loss suffered by members from the death of plough cattle can be minimized. At present if a bullock belonging to a member dies, not only is the tangible and collateral security diminished that the society has for any loans already borrowed by him, but a fresh advance has to be given to him in order that he may replace the deceased animal.

The difficulty has been met in European countries by co-operative societies for the insurance of such cattle. At the conference held in January 1912, Mr. Fremantle outlined a scheme for similar societies in this province. Unfortunately central societies did not take up the idea with any eagerness and there was also some doubt in the minds of competent authorities whether, in the absence of adequate data regarding cattle mortality and also in the absence of sufficient arrangements in rural parts for the prevention and scientific treatment of cattle disease, cattle insurance societies

* A paper read at the Provincial Co-operative Conference held at Lucknow in February 1916.

were likely to be successful in this country. Such societies have however now been in operation in Burma for the last five or six years and they have so far proved eminently successful. In view of the great importance of the subject both from the agricultural and co-operative standpoints, the United Provinces Government is anxious that a few experimental societies should be started under favourable conditions and the scheme given a fair trial. Accordingly, after careful deliberation, a small number of societies has been registered in the Mainpuri District, and it is hoped that in other suitable localities co-operators will endeavour to establish a few societies in order to gain experience; if they are successful as there is every reason to hope that with sufficient safeguards they will be successful, such societies can be organized all over the province.

Model by-laws and other particulars may be obtained on application to the Registrar and his staff will give all necessary aid. Societies should be organized only in localities where credit societies have been successfully working and the people are familiar with co-operative ideas. Also only such localities should be chosen in which the cultivators use good plough cattle and appreciate their value. Tracts where the agriculturists trade in cattle, frequently buying and selling them, should be avoided. The members should belong to one village or to two or three contiguous hamlets. They should insure as many as possible of their eligible cattle. At present insurance is confined to healthy bullocks and male buffaloes between the ages of 4 and 12 years. Premium has to be paid every six months (or the insurance lapses) on the value of the animal which is assessed by a valuation committee appointed by the society. The rate of premium has for the present been fixed at one pice per rupee for the six months. This may have to be altered with experience. If the animal dies during the course of the six months, the owner will get back two-thirds of its value after deducting whatever he may be able to realize by selling the hide, etc. Provision is made to secure preventive measures in case of epidemics and also for treatment for sickness. No compensation is given if the animal dies through the neglect of the owner. For the present the cattle insurance society will bank with the district or central bank of the

locality, and if, at the end of the experimental stage of the few selected societies, there is any loss, it will be made good by the Government. If the scheme proves successful and the number of societies increases, a re-insurance society will be organized. This cannot however be done for a year or two or until cattle insurance societies are in operation in different parts of the Province, so that the risk can be spread out and thus minimized.

As the writer has recently had an opportunity of studying on the spot the work of the Burma cattle insurance societies, a brief account of their special features may be interesting. Burma has a great advantage over us in this respect for cow's milk is seldom used for human consumption. Consequently the calves get all the milk and the cattle are more healthy and stronger than in this province. There is also plenty of grazing except in certain seasons of the year. The village and tenure systems of Burma moreover enable the villagers to prevent individuals from adopting practices pernicious to the general welfare of all the cattle in the village. The cattle insurance societies have given further stimulus to this system and sanitary measures for the protection of the cattle are adopted in every village as soon as any disease or epidemic is threatened. It is hoped that in this province also cattle insurance societies will help in this direction.

In Burma the area of a cattle insurance society is ordinarily limited to one village. Membership is practically confined to the members of a credit society. (The Registrar of Burma does not consider this rule to be essential, but it has been adopted in order to minimize the chances of dishonesty on the part of the cattle insurance society in its dealings with the re-insurance society. Any such dishonesty can now be punished by the closing of the credit society, which is bound to prove a severe misfortune to all its members.) Members are encouraged to insure all their eligible cattle, but at present they are not compelled to do so. Plough bullocks and buffaloes between the ages of 4 and 12 are insurable. The valuation is made every six months when the premium has to be paid. The present rate of premium is five per cent. per annum. On the death of an insured animal, an indemnity of two-thirds of the value assessed, less the price of the hide and carcase, is paid out.

The valuation work seemed to me to be easier in Burma than it is likely to be here. The cattle are more or less of the same value if of the same age. In other words the standard of care bestowed on the animal from the time of its birth is uniformly high and there are not many different breeds to be taken into account. It may also be noted that the meat of a dead animal is eaten by all classes of Burmans. The price of the carcase is thus a substantial sum and the indemnity payable is appreciably reduced thereby.

A re-insurance society has been organized for the whole of Burma of which the Registrar is at present the honorary and *ex-officio* manager. Half the premia collected by the insurance society is deposited in the local credit society. The other half is sent to the re-insurance society along with a list and particulars of cattle insured and their valuation every half year. If any animal dies, half the indemnity that has to be paid comes from the re-insurance society, the remaining half has to be made good from the funds of the primary insurance society. The latter has two separate funds, *viz.:* (1) the general fund consisting of all premia realized during the year, and (2) the reserve fund consisting of fines, entrance fees, donations, profits of previous years, etc. In the event of the funds received as premia during the year proving insufficient to meet the claim of half the indemnity payable by the primary society, half of the reserve fund may be drawn upon in any one year with the Registrar's sanction to meet the deficiency. If the funds are still insufficient the indemnities for all animals that have died during the year will be proportionately reduced. I am informed by the Registrar that so far no society has suffered a deficit. The re-insurance society was organized only about a year ago. It banks with the Upper Burma Central Bank, which is the Provincial Co-operative Bank for Burma.

In Burma only a few tracts have any district or central bank. The link between the Provincial Bank and the primary credit society is the "Guaranteeing Union." A cattle insurance society becomes a member of the local union in order to secure supervision from it, but undertakes no financial responsibility in it.

PROTECTIVE INOCULATION OF STOCK IN INDIA.*

BY

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In relation to the control of infectious diseases of stock, as in other directions, India presents problems that are essentially her own and which demand for their solution special study and treatment. Some of the animal diseases prevalent are peculiar to the country and, in a few, the framing of prophylactic measures is at present hindered by our lack of precise information regarding their causal agency, mode of transmission, or other essential feature of their epizootiology. However, in the case of the more important microbial diseases of cattle, which are responsible for so large a proportion of the total stock mortality in India, the same difficulty does not exist and methods of prevention and eradication are well known and practised with success in other parts of the world; but similar methods are often entirely inapplicable under existing conditions to cattle owned by natives of India. This applies most forcibly to such measures as slaughter of affected and in-contact animals, segregation and the limitation of movement of stock in infected areas, but it is also true, to a considerable extent, of protective inoculation, which is the only remaining means at our disposal of checking the enormous yearly loss of stock from disease.

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* A paper read at the Third Indian Science Congress, Lucknow, 1916.

At the present time the only diseases for which legislation is in force are Glanders, Surra, Epizootic Lymphangitis and Dourine. These all concern equines principally or solely and against none of them is inoculation practised. Thus, even in those diseases for which we possess prophylactic sera or vaccines, no application of these agents can be made without the full consent of the individual owners.

The difficulties to be overcome by the Veterinary Department in securing voluntary acceptance of inoculation and the requirements to be satisfied by the bacteriologist in respect of the materials employed will be readily appreciated when it is remembered that the great majority of stock owners are ignorant of the meaning of the operation and suspicious both of the effect of the injection and the motives of the operator; but, in addition to these opposition factors which will be overcome in time by teaching and demonstration, there is the strong religious prejudice of Hindus against any form of operative interference with their cattle, even to the insertion of an injection needle in many cases, while an inoculation which endangered to the slightest degree the life of the animal, would not be tolerated under any circumstances.

The first essential therefore of a serum or vaccine for use on cattle in India is safety in action. In other countries stock owners are prepared to sustain some loss from inoculation provided the remaining animals are immunized and the losses do not equal those experienced from the natural disease. Under these circumstances it is frequently possible to employ methods that confer strong and lasting immunity but in this country their application is very limited.

Secondly, immunity should be established rapidly. This can only follow directly after the inoculation when anti-serum is employed, as will be explained later, but the almost immediate cessation of deaths amongst the treated animals, in this case, is a very valuable object lesson and largely contributes to the acceptance of inoculation in districts where the procedure is viewed with distrust.

Obviously the immunity should be strong enough to resist all natural means of infection though it must not be forgotten that

acquired immunity is seldom absolute even for a time and several causes may lead to its breakdown.

A consideration of great practical importance is simplicity of the operation, as the inoculating staff is usually small, co-operation of the owners difficult to secure, areas large, and checking of animals treated often impossible as the owners object to any form of marking; thus the need for more than one injection, especially if they have to be separated by an interval of several days, is a serious obstacle to the successful application of the treatment.

The question of duration of immunity has to be made dependent, to a large extent, on the previous considerations and will be discussed when the different methods are reviewed.

The bacteriologist having obtained a serum or vaccine that meets, as far as possible, the requirements just enumerated, the task of securing its acceptance and of applying it in the limitation of the spread of the infective disease in question falls upon the staff of the Veterinary Department. Under existing conditions no attempt at the total eradication of any epizootic cattle disease is possible; the freedom of movement of stock by which contagion is spread, the inability to destroy sources of infection and carry out adequate disinfection, the character of parts of the country, the vast areas covered and the relative smallness of the staff engaged, render such a task hopeless. All that can be done is to deal with outbreaks as they occur, by inoculating, without delay, all cattle in the vicinity, thereby preventing the contagion from finding further suitable hosts in which to propagate, and causing it to die a natural death. The extent to which these efforts will succeed largely depends on the amount of co-operation given by the stock owners themselves and the sufficiency of the veterinary staff, both supervising and subordinate, that is available to carry out the work. The first can only be secured by education and demonstration, by which means the confidence of the people will be obtained; while the provision of the second factor rests with the authorities and the various veterinary colleges.

These are in brief the broad lines on which the practical application of protective inoculation of stock in this country is based

the details of their working and the measure of their success may be judged from the reports of the Superintendents of the Civil Veterinary Departments in the various provinces and from the rapid increase, during recent years, in the demand for sera and vaccines.

Before proceeding to discuss the different types of immunity and the various sera and vaccines at present employed, it may be of interest if a short account is given of the initiation of prophylactic measures against animal diseases in this country.

The earliest action appears to have been taken in Madras as long ago as 1866. An Act was then passed for controlling the spread of disease in the province but, as the report of a Commission appointed in 1890 shows, it was never fully worked, and in fact could not have been enforced under the existing conditions. The Government of India made a more serious attempt to cope with the subject of stock diseases in 1868 ; they appointed a Commission of enquiry which toured the country and submitted a report three years later. The difficulties of the question were dealt with and stress was laid upon the necessity for a thorough expert examination of rinderpest and the other cattle diseases with the object of discovering preventive vaccines, but no legislative control was suggested. Later the Governments of different Provinces were roused, by the seriousness of the losses among cattle, to propose legislation, but in every case the matter was allowed to drop owing to the difficulties presented.

It was only natural that the early discoveries of Pasteur in connection with the protective inoculation of animals should have attracted the notice of the Government of India and have led them to invite his assistance ; this they did in 1884. Although rinderpest was the disease for which a protective agent was most urgently required, the vaccines offered in response to the Government's enquiries were for anthrax. This was in fact the only animal disease for the prevention of which any vaccine was then known, but there seems to have been some misunderstanding on this point at the time. However, India appears to have offered such an inviting field for commercial enterprise in the realm of animal vaccines

that the scientist formed a company, designated the Animal Vaccine Company, Ltd., solely for the purpose of supplying anthrax vaccine to India and tried with great perseverance to induce the Government to commit itself to wholesale vaccination of cattle, on terms that would have ensured handsome profits to the company.

Two Veterinary Officers and two Indian students were sent to Pasteur's laboratory to be trained in the application of the vaccines and a large quantity of the material must have been sent out, since some years later Pasteur claimed and was paid £800 sterling for training the officers and supplying 50,000 doses of vaccine.

Either as the result of the all too evident commercial motives of the Animal Vaccine Company or of reports from Veterinary Officers in India, or both, the Government declined to enter into an agreement for the supply of vaccine and decided to delay putting into operation any large scheme of vaccination until a more thorough investigation of the nature and prevalence of cattle diseases had been undertaken by competent officers. At this time also doubts were expressed as to whether the anthrax reported in India was the same disease as that existing in Europe and the danger arising from the possibility of introducing a new disease by means of the vaccines was pointed out. This uncertainty arose from the confusion that prevailed at the time in the diagnosis of cattle diseases, deaths from a variety of different causes being returned as anthrax. On this account also the impression was created that the disease was responsible for a much larger mortality than was actually the case.

Accordingly a Civil Veterinary Department was formed and in 1890 certain Veterinary Officers were selected to make what was designated a "bacteriological survey." In the same year Dr. Lingard was appointed as Bacteriologist and given a laboratory at Poona in association with the College of Science.

Two years later, both the Civil Veterinary Department and the Bacteriological Survey were placed on a more definite footing. Mr. (now Colonel) H. T. Pease became Superintendent of the Survey and the functions of the office were defined as being (i) to map out the distribution and prevalence of cattle diseases, (ii) to advise

Veterinary Officers regarding diagnosis, and (iii) to co-operate with the Bacteriologist in the conduct of his investigations.

Meanwhile the location of the laboratory at Poona was found to be unsuitable, both for experimental work and vaccine preparation. Accordingly, the Imperial Bacteriological Laboratory was established in its present situation at Muktesar, in the Kumaon Hills, and sufficient buildings were erected to allow of work being commenced there in 1895.

All this time the Animal Vaccine Company continued their efforts to secure the adoption of the Pasteur Anthrax Vaccines. Representatives were sent out and much correspondence took place. It was not until the year 1900 that the Government of India having received Dr. Lingard's report on the subject, finally refused to entertain further any proposals that the Company might make regarding cattle inoculation.

The grounds on which Dr. Lingard based his objections to the employment of the products of Pasteur's Company were that all vaccines required could be prepared and tested by the Government's own experts without the necessity of paying large sums of money to a foreign business concern, and that the available evidence went to show that anthrax was not sufficiently widespread to justify immunization of cattle against it on a large scale. A feature of the Pasteur vaccines that does not appear to have been realized at the time is, that they are not free from risk, and that in India this constitutes a serious objection to their employment.

The protracted negotiations between the Government of India and the Animal Vaccine Company are described at some length in a summary written by Sir Edward Buck in 1896 and their only interest now lies in the fact that they undoubtedly led to the first establishment in this country of a laboratory for research in stock diseases, and the manufacture of protective agents for their control.

Since 1895, this work has been carried out at the Muktesar Laboratory under the direction first of Dr. Lingard and then of the late Lt.-Colonel J. D. E. Holmes ; to these two workers the credit must be given of initiating and organizing the methods of serum and vaccine preparation in India on the scale at present in operation.

In order to make clear why certain methods of protective inoculation are free from risk while in others there is an element of danger, and to explain, as far as possible, the reasons for the variations in the character and duration of immunity produced in different ways, reference may here be made to the main points involved in the action of those sera and vaccines which are employed in India at the present time.

By making this restriction the production of immunity against diseases due to protozoon infections, such as Redwater and the other Piroplasmoses, will not be discussed; several forms of this group of diseases are very widely spread throughout India, but all the native breeds of cattle have a high degree of immunity against them and in consequence they have attracted little attention. In relation to the importation of pedigree stock from England and other countries more or less free from these infections, the subject however is of great interest and practical importance and will require investigation in the near future.

It is a well-known fact that when a person or animal recovers from an attack of a bacterial disease, they are protected usually for a long period against a further attack of the same disease and as a result are said to have acquired immunity.

All the Indian stock diseases in which inoculation is practised are caused by micro-organisms which produce their injurious effect in one of two ways, either (i) by spreading through the body in the blood or lymph stream as in anthrax, rinderpest, etc., or (ii) by remaining at the point of infection and forming toxins which are absorbed and poison the cells of the body, as is the case in tetanus. Immunity in both classes is due to the formation in the body of certain substances which, according as they aid in the destruction of the invading organisms or neutralize liberated toxin, are known as bacteriolysins and anti-toxins respectively.

The animal body, either as the result of an attack of a particular disease or the injection of various animal cells and fluids or poisons of different kinds, is capable of forming many other varieties of anti-body each having some specific action on the agent that provoked its formation, but

any account of these is outside the scope of the present paper.

The bacteriolysins and anti-toxins, like the other anti-bodies, circulate in the blood plasma and body fluids and after recovery from the disease the tissues responsible continue to produce them for some time, thus maintaining the protection. For this reason such a recovered animal is said to possess an active immunity against that particular disease. When an actively immunized animal receives large and repeated injections of the organism in question or its toxin, as the case may be, its tissues are stimulated to form anti-bodies in greatly increased amount and the animal is then said to be hyper-immune. The anti-bacterial and anti-toxic sera used in practice for inoculation are obtained from the blood of such hyper-immunized animals.

If a susceptible animal receives an inoculation of anti-serum it will at once acquire an immunity, the strength and duration of which will entirely depend on the quantity of anti-body contained in the injected serum; the tissues of the injected animal itself will form no anti-bodies so that its state of insusceptibility is known as passive immunity.

Since the serum and its contained anti-bodies are eliminated or neutralized in the same way as other foreign substances entering the body, passive immunity is of short duration, usually lasting only about two to four weeks. This is the serious drawback to the production of immunity of the passive variety, which otherwise possesses the very desirable features of absolute safety and immediate protection. Active immunity, on the other hand, is usually of long duration so that if a method can be found of establishing this variety without the dangers and drawbacks of a natural attack of the disease, there is an obvious advantage in its employment. The first discovery of a means of accomplishing this was made by Jenner, in 1796. This observer noticed that persons who had suffered from cow-pox, a benign eruptive disease of cattle, escaped contracting small-pox, then very prevalent in England. Accordingly he introduced the method of vaccination with the infective lymph from cow-pox lesions by which human

beings are made to pass through an attack of the mild bovine form of the disease in order that thereby they may develop an immunity against the graver infection.

Although it was not until nearly a century later that any very clear ideas on the subject of immunity came to be formulated, Jenner's discovery remains the greatest therapeutic fact of all time and to this day one of the most successful methods of artificial immunization in existence.

The basis of modern methods was laid by Pasteur in 1880 when he demonstrated that the virulence of cultures of anthrax bacillus could be reduced so that their inoculation in suitable doses failed to produce a fatal attack of the disease but gave rise to strong active immunity against it. Later many other means were devised for giving active immunity against different diseases in all of which the living organisms were employed, but the danger minimized either by introducing them into a tissue unfavourable for their multiplication or by attenuating their virulence by physical, chemical or other means before inoculation. By these methods, in which living germs are injected, a fairly strong immunity can be provoked, but either on account of the very variable susceptibility that always exists among individuals of any one species, or the re-acquirement of virulence by the organisms, there is always a certain amount of danger of a fatal attack of the disease being set up in a proportion of cases. The average fatalities caused in this way may be so small as not to be worth consideration in other countries, but they are usually sufficient to prevent the adoption of such procedures in India.

More recently it has been found that a degree of active immunity can be produced by the injection of the bodies of bacteria killed in various ways. This procedure is quite free from danger and is that employed with such marked success in typhoid and plague inoculations in the human subject. The results obtained in the case of animal diseases have not been so striking but the method has been adopted in certain cases with good effect. The resulting immunity lasts considerably longer than that following the injection of anti-serum but as always occurs in active

immunization there is a short period, usually three or four days with dead vaccines, following the injection, during which the animal has an enhanced susceptibility. This so-called negative phase is due to the absorption of the existing anti-bodies and lasts until the tissues have begun to produce the specific anti-bodies that afford the protection; the subsequent period of immunity is known as the "positive phase."

As a consequence of the researches of Sir A. E. Wright and others killed vaccines are now largely used in the treatment of bacterial infections, both in human beings and animals, but since the subject is outside the strict interpretation of the title of this paper, it can only be mentioned here.

What may be described as a combination of passive and active immunization has been employed with marked success in certain diseases, and is applicable to almost all those for which a strong anti-bacterial serum can be prepared. The method is termed "serum simultaneous" and comprises an inoculation first of anti-serum and at the same time or shortly afterwards an injection of a culture of the organism or of material containing it. In this way the animal is given an immediate passive resistance which prevents a subsequent attack of the disease following from the inoculation of the living germs, or so modifies it as greatly to lessen the risk of a fatal termination. In either case an active immunity is set up, the strength and duration of which depends as a general rule on the severity of the reaction produced.

Since however, it is not always possible to establish a correct balance between the amount of anti-serum and infective material required in different individuals whose susceptibilities may vary considerably, the method is not without danger and so can only be employed when the owner is prepared to take the risk, and in places where the disease already exists.

Having thus defined the general lines on which immunity to certain classes of infective disease can be established, we may now consider the individual diseases more in detail, and the first in point of importance is rinderpest.

The Commission appointed by Lord Mayo's Government reported in 1871 that "Rinderpest is the murrain to which a far greater share of mortality among cattle is due than all other causes put together" and this would appear to be still true at the present time.

A leader writer in the *Pioneer* of 1893, quoted by Lingard, placed the loss to stock owners caused by rinderpest at three crores of rupees in a bad year. Last year the returns of the Superintendents of the Civil Veterinary Departments for the various provinces showed that 1,10,397 bovines and 1,232 sheep were reported as having died from rinderpest, but it is certain that a large number of outbreaks still remain unrecorded; the losses occurring in the Native States are not included in these figures, but they are certainly heavy so that the total yearly deaths from this disease in India must be very great.

Much of the early investigation work on protective inoculation against rinderpest was done in South Africa by Koch, Turner, Kolle, Theiler, Edington, Pitchford and others just prior to the starting of the Muktesar Laboratory; the first line of inquiry to which the officers of that institution therefore devoted their attention was to ascertain which of the various methods put forward was most suitable to Indian conditions. At the request of the Government of India, Koch visited Muktesar in 1897 and gave a demonstration of his bile process, but after much experimental work, extending over several years, it was decided that the serum alone method was the only one which satisfied the necessary requirements for adoption in India. Serum inoculations were accordingly started in the year 1900 when 1,730 doses were issued. At first its acceptance by stock owners was slow but as its value came to be realized the demand increased rapidly. In 1904 the output from Muktesar was 56,483 doses, in 1905, 1,24,015, by 1911 it had risen to 7 lacs of doses, while last year no less than 13½ lacs of doses were supplied to India alone. At the present time the demand for rinderpest and other sera and vaccines appears to be mainly regulated by the number of qualified veterinary assistants available to carry out the inoculations in the various provinces. The staff of these is now much below requirement or even sanctioned strength, partly on account of the War

and partly owing to the veterinary colleges being unable to pass out a sufficient number of graduates to fill the vacancies.

Cattle are by far the greatest sufferers from rinderpest but sheep and goats may also become affected and deaths especially in imported breeds, may be numerous. The causal agent is present in the blood and discharges of affected animals but is too minute to be visible even under the highest power microscope; it is therefore referred to as an ultra-microscopic virus and since cultures cannot be obtained, blood from infected animals which contains the virus, is used in immunization and hyper-immunization for the production of the anti-serum.

The process of manufacture has been much improved from time to time and that which is now adopted is briefly as follows:—Bulls of the highly susceptible Kumaon breed and buffaloes are employed and are first immunized by the serum simultaneous method already referred to, by which each receives a standard dose of anti-serum and at the same time a small injection of blood from an animal suffering from rinderpest. As a result the animal passes through a mild attack of the disease and recovers in about 10 to 12 days. At the height of the reaction some blood which then contains virus is taken for hyper-immunizing other serum making animals. A week after complete recovery the animal is bled once for serum and a few days later receives an injection of from one to two litres, according to its weight, of a mixture of virulent blood and potassium citrate solution, the latter being added to prevent clotting and aid absorption of the blood. On the 8th, 12th and 16th days after the injection the animal is bled for serum, the amount taken being regulated according to the weight and condition of the animal. After a rest of a week or more the animal is again injected with virulent blood and then bled as before, these processes being repeated as long as the animal absorbs the injections completely. The frequent bleedings cause little or no interference with the general health of the animals. The serum is separated from the blood either by centrifuging or clotting; a modification of the latter method has recently been introduced by which an increased yield is obtained. When about 600 litres of serum from various bleedings and animals

have been prepared, the whole is mixed and tested in graduated doses on susceptible hill bulls. In this way the strength of the serum is ascertained and only that is issued which will protect against an injection of virulent blood in doses of 72 c.c. per 600 lb. body weight in the case of hill bulls. This is equal to 4 c.c. per 600 lb. in plains cattle; smaller doses are usually sufficient to prevent a fatal attack in the test animals but in order to provide a margin for safety the standard dose issued is 5 c.c. for plains animals. As however the susceptibility of plains animals varies considerably this dose may with advantage be increased in those outbreaks in which a high mortality indicates low resistance to the disease.

As has already been explained, the serum gives an immediate passive immunity lasting about two to three weeks or longer if the dose is increased. This would seem to be of little practical value but actually it is found to fulfil requirements in the majority of outbreaks at the present time. All that can now be attempted is to check the mortality in places where the disease is active and prevent, if possible, an extension of the infection; accordingly, the still healthy cattle in the neighbourhood receive an inoculation of serum and are then allowed to mix with the sick or graze over infected ground. In this way a good proportion of them pass through a mild attack of the disease and develop an active immunity of long duration. To all intents and purposes this is a natural method of serum simultaneous inoculation, natural infection taking the place of the injection of the virus. It is not so reliable but is not open to the same objections as the double inoculation and in practice is found to give satisfactory results. The treated animals that do not become infected are nevertheless protected for a sufficient time to allow of the sick animals either dying or recovering, thus getting rid of the source of further infection. A few deaths after serum inoculation are usually reported but last year the returns show that these amounted to just 0·4 per cent. of the treated animals* and in a considerable

* Rinderpest in 1914-15, Reports of Civil Vety. Dept.

Number of deaths before inoculation	44,450
Number of animals inoculated	4,39,470
Number of deaths after inoculation	1,765

proportion of them the disease was probably well established before serum was given so that the actual number not immunized must be very small. Anti-rinderpest serum has very little curative effect once symptoms have developed.

In the case of cattle the property of Government or of owners who are prepared to take the risk of a small mortality in order to have all their cattle actively immunized, the most satisfactory method is the 'serum simultaneous.' It may be carried out before the disease has made its appearance, thus avoiding any initial loss, and with proper precautions there should not be any mortality from the inoculation; the immunity given will be of long duration. The necessary requirements are actively virulent blood and anti-serum of accurately determined potency in properly regulated doses. The first has always been considered difficult to obtain in the absence of the close proximity of the disease as past experience has shown that in the plains of India the virus quickly perishes in drawn blood and so cannot be transported from a distance with any certainty.

Recent investigations, which are still in progress, have shown that two essentials for preserving the rinderpest virus in drawn blood are a low temperature and the taking of the blood early in the attack, that is, at the time of the first marked rise in temperature, before any development of anti-body has occurred. The exclusion of air or oxygen is also an advantage. When these conditions are fulfilled, there appears to be no difficulty in preserving the virus for weeks or even months.

The method of testing the potency of the serum has already been explained; the fixing of the correct dosage can only be effected by observations on small numbers of each of the different breeds or classes of animals to be immunized. This is particularly necessary in the case of imported pedigree or half-bred stock which have a high susceptibility to the disease. By commencing with large doses of serum and gradually reducing them in subsequent tests such determinations could be made without serious loss.

There is evidence to show that even when the dose of serum is so large as to prevent any reaction resulting from the virus

inoculation, a degree of active immunity is nevertheless established, but it is doubtful whether this is of long duration.

While undergoing immunization the cattle must be strictly isolated as during the reaction they are capable of transmitting the disease to healthy stock, and subsequently the sheds in which they have been kept, should be thoroughly disinfected.

Hæmorrhagic Septicæmia is an acute, rapidly fatal disease affecting essentially bovines though horses and elephants sometimes become infected. During 1914-15, 3,395 deaths from this disease were reported, but the actual number is undoubtedly much greater.

The causal bacillus can live in moist soil and is probably very widely distributed. Outbreaks of the disease are most frequent during and after the rains when the conditions are favourable for the multiplication of the organism and the excessive moisture reduces the vitality and resistance of the animals. During drought also the disease may occur; scarcity of food then weakens the cattle and renders them more susceptible to the infection, which they probably obtain from drying-up tanks and river beds. Once the disease has started, it may spread by direct contagion but seldom assumes the epizootic character of rinderpest. It runs a very rapid course, death usually occurring two or three days after infection in a large proportion of the animals attacked.

Lingard first prepared an anti-serum against this disease in 1905, by the injection of small doses of culture of the organism into cattle. Holmes greatly increased the strength of the serum by employing larger injections of culture. A considerable number of doses at 5 c.c. each were issued between 1905 and 1908 but early in the latter year its use was discontinued as the protection given was considered to be too short for practical purposes. In 1910 Holmes introduced the stronger serum at 15 c.c. per dose and the demand rapidly increased from 1,800 doses the first year to 77,328 doses in 1914-15. This figure has already been exceeded during the first nine months of the current financial year.

In dealing with outbreaks of the disease the animals exposed to infection are inoculated with anti-hæmorrhagic septicæmia serum; this gives them an immediate passive immunity lasting

for three to four weeks, by which time the sick animals have usually either died or recovered. The disease not being as readily conveyed by contagion as rinderpest and its course being more rapid, there is not the same likelihood of producing an active immunity by the mixing of inoculated with sick animals, so that no lasting protection results in most cases. Active immunity may be obtained by a serum simultaneous inoculation, a small dose of culture of the organism being given shortly after the serum. Owing to the great variation in susceptibility of different individuals it is difficult to fix accurately the dose of serum necessary to control the reaction caused by the injection of culture so that a small percentage of losses must be expected. For this reason also the method should not be adopted in areas free from infection.

A serum simultaneous inoculation is employed at Muktesar to first immunize the hili bulls and buffaloes from which serum is to be obtained. Then, at intervals, after recovery from the first reaction, the animals receive gradually increasing doses of virulent culture of the organism, injected subcutaneously, until they are highly immune and can tolerate the injection of 1 litre or more of a broth culture. They are bled three times for serum and again receive culture in still larger doses, the subsequent bleedings and injections following each other as in the preparation of other anti-sera.

In certain districts hæmorrhagic septicæmia appears with such regularity at particular seasons of the year, that a safe method is required of giving a more lasting immunity than serum can confer, to be applied before the disease has actually broken out. To meet this need as far as possible, a vaccine containing only killed organisms was prepared in 1908; since its introduction the demand has rapidly increased until in 1913-14, 2,40,000 doses were issued. It is perfectly free from danger and in doses of 5 to 10 c.c. provokes a degree of active immunity which lasts several weeks. Owing to the fact that a "negative phase" of about four days' duration follows the inoculation, vaccine should not be made use of when the disease is already active, otherwise deaths are likely to follow.

Experiments are now being carried out with the view of lengthening, if possible, the period of immunity that can be produced by dead vaccines but the great susceptibility of cattle, and especially of buffaloes, makes this extremely difficult of accomplishment by means of a single inoculation.

True anthrax is responsible for a large number of deaths yearly in cattle, horses and sheep, but outbreaks are usually sporadic and the infection does not spread rapidly among the animals of a particular locality. Occasionally, however, a considerable number may become infected from one source at the same time. As with hæmorrhagic septicæmia the bacillus lives in the soil and in some districts is more prevalent during and after the rains. Most animals are very susceptible when inoculated with a small amount of culture of the bacillus and a high percentage succumb but the native breeds of cattle are curiously resistant to this form of the disease unless their vitality has been reduced by some means. Subjection to unfavourable conditions also probably plays a considerable part in aiding natural infection by anthrax, just as it does in hæmorrhagic septicæmia.

As already mentioned, Pasteur was the first to confer artificial immunity against anthrax on animals; this he did by means of cultures of the organism attenuated in virulence by growing in oxygen at high temperatures. He employed two vaccines, the first being more weakened than the second, and these were injected at an interval of ten or twelve days. Although largely used on the Continent at the present time, the results obtained with Pasteur's vaccines have not always been favourable, and in most other countries their employment is strongly discouraged. Several modifications of Pasteur's method of attenuating the cultures have since been practised but these in common with the original vaccines have the following objections :—The immunity resulting is variable and uncertain, deaths from anthrax following the use of the vaccines, especially the second, are not infrequent and the danger of disseminating the disease in this way is by no means negligible. In horses and sheep the vaccines are unsafe and considerable mortality sometimes follows their injection. For these reasons

attenuated vaccines are very unsuitable for use in India, though, as previously stated, they were not the ones put forward when the Government decided in 1900 to have nothing further to do with the Pasteur vaccines.

Anti-anthrax serum was first prepared by Sclavo in 1895 and subsequently by several bacteriologists but no very extensive use appears to have been made of it for the protection of animals.

Lingard introduced anti-anthrax serum in India in 1902. He prepared it from cattle by repeated inoculations of living culture of the organism in a similar manner to that described for the production of hæmorrhagic septicæmia serum. Large amounts of anthrax serum were employed in the field during the years following its introduction up to 1908, but it was then found that a large number of deaths attributed to anthrax were actually caused by the organism of hæmorrhagic septicæmia and accordingly its use was restricted to outbreaks in which the diagnosis was confirmed microscopically; at the same time the issued dose was increased to 15 c.c.

In 1913-14 the demand increased to over 20,000 doses, and last year showed a further slight increase; in the earlier part of the current year anthrax was very prevalent and over 40,000 doses have been issued during the past nine months to all parts of India.

Serum injections are carried out on cattle that are actually exposed to risk of infection in places where one or more deaths from the disease have occurred. Protection is given for three or four weeks only but this checks the immediate spread of the disease and allows the source of infection to be dealt with by disinfection or other means. If necessary the inoculation of serum may be repeated. For the treatment of anthrax in man, anti-serum has given very good results, and where opportunity offers, could be similarly employed in the case of animals; unfortunately the disease is usually so rapidly fatal that death occurs before treatment can be applied.

In places where anthrax frequently appears and the owner is prepared to accept the risk of a few deaths from the inoculation, an active and lasting immunity may be produced in cattle by the "serum simultaneous" method, using either virulent or attenuated

culture at the same time as the serum. Owing to their great susceptibility this method is too dangerous in horses and sheep. Experiments are now in progress in which killed cultures are being tested as to their immunizing value. These are free from risk but it is not yet certain that a useful degree of active immunity can be induced by their means.

Another seasonal and sporadic disease of cattle and sheep formerly confused with anthrax but caused by a distinct organism, is **black quarter** or **quarter evil.**

The French name, charbon symptomatique, is also sometimes used, but since this serves to perpetuate the old confusion with anthrax, of which the French name is charbon, it ought to be dropped, and one of the more accurately descriptive English names adopted.

The black quarter bacillus can also exist in soil and on gaining entranee to the body, developes in the muscles, usually of the hind quarter, causing local symptoms and rapid death in the great majority of animals becoming affected.

A serum for this disease can be prepared, but as it only affords protection for a short time and the spread of the infection by direct contagion is of infrequent occurrence, it possesses little practical utility.

In most countries vaccines, prepared according to the original method of Arloing and Corniven or some modification of this, are employed and give highly satisfactory results. As the causal bacillus is found in great numbers in the affected muscles of animals which die from the disease, this tissue or the juice expressed from it, is employed in the preparation of the vaccines.

By Arloing's method a first and second vaccine are prepared by heating the dried muscle at definite temperatures for a short period; greater heat being applied to the first than to the second; in this way the organisms in the first vaccine are more attenuated than in the second and each is inoculated separately at an interval of ten days.

Vaccines made according to this method were first issued by Lingard in 1906, but owing to the necessity for two operations the demand was not large.

Holmes in 1909 tested a single vaccine made by mixing in fixed proportions first and second vaccines, prepared somewhat after the method of Arloing. This gave very satisfactory results, and the average yearly issues since its introduction have amounted to nearly 16,000 doses.

To simplify its inoculation the vaccine is supplied in the form of a pillule which is inserted under the skin by means of a special injector. In as much as the vaccine contains living, though weakened organisms, its use is not always free from risk, but in practice the deaths have been so rare that no objection to the inoculation has been raised on account of them ; last year out of 4,902 cattle inoculated only 10 or 0·2 per cent. subsequently died of the disease either as the result of the injection or owing to its failure to give immunity. As the disease is not transmitted by direct contagion to any extent there is little danger of introducing it by the vaccination although this is only recommended in places where the disease is known to have already occurred.

An active immunity lasting at least several months is established, and since young animals are those most susceptible, one inoculation will usually carry them over the most dangerous period of their lives. In badly infected districts the injections may be repeated each year.

The sera and vaccines already referred to are used almost entirely in outbreaks of disease in bovines ; the majority of diseases of horses and sheep in India either do not lend themselves to protective inoculation, as with surra and glanders or such cannot be attempted owing to our ignorance of the causal agent itself, as is the case in *kumri* and several other local diseases of stock not yet investigated. There is reason to believe that some of the latter class are caused by plant or other poisons and not by micro-organisms, in which case protective inoculation can hardly come into operation to aid in their prevention.

The only purely equine disease for which protective agents are issued from Muktesar, is **strangles**. As a general rule, this disease does not call for prophylactic measures in India, but in the Government Remount Depôts the losses and trouble caused by it are

frequently very considerable. This is especially so in the country-bred depôts where large numbers of yearling horses are collected together; here the chances of infection are great and the young animals show a marked susceptibility.

Since 1909 anti-strangles serum has been prepared by the injection of horses, mules and cattle, with increasing doses of culture of the causal organism, the *streptococcus equi*. In other countries similar anti-sera have been said to confer protection against the disease, but in these the age at which the horses are most liable to infection is four to five years, whereas in the Indian depôts they come in at 11 to 13 months old and are under the disadvantage of having just been weaned. At all events in these young animals anti-strangles serum has unfortunately been found to give very little protection although in the treatment of the disease its use is of marked benefit. At present it is chiefly employed as a curative agent.

Experiments are now in progress with various dead and living vaccines of the organism, and it is hoped that some means will be found of conferring a sufficient degree of immunity upon the young stock, on entering the depôts, to carry them over their most dangerous period.

In India **tetanus** is very widespread, and any of the domesticated animals may become affected, but the great majority of cases are seen in horses. The tetanus bacillus gains entrance to the body through deep wounds and produces its effect on the animal body by means of the toxin which it forms in the wound and which becoming absorbed acts on the nervous system. By obtaining this toxin from cultures of the bacillus and injecting it in gradually increasing doses into horses, a strong anti-toxic serum can be prepared. This when injected into an animal in suitable dose protects it against infection by the organism for a period of three or four weeks. It is employed chiefly on horses that have contracted penetrating soil infected wounds, in the same way that it is injected into wounded men at the front, to prevent the development of any tetanus germs that may have entered. It is also given in the treatment of cases of the disease but the benefit derived is not always very marked, either in man or animals.

Anti-tetanic serum was prepared at the Muktesar Laboratory in 1906, but as the demand was too small to justify the expense of its manufacture, this was discontinued the following year; the product of various reliable English and American firms can be obtained on the Indian market.

Once the value of a biological product in the prevention or cure of a disease has been demonstrated, there is a common tendency for inexperienced persons to form an exaggerated idea of the effects and possibilities of the agent; to avoid disappointment it is necessary, therefore, to emphasize that all methods of establishing immunity are liable to break down in a proportion of individuals whose susceptibility is abnormal. What is aimed at is to give as strong and lasting an immunity as the limitations of Indian conditions will allow, and the periods of protection stated for the different sera and vaccines apply to the normal animal, but in all cases a few individuals will be found in which it will be either shorter or longer, according as their susceptibility is greater or less than the average. The importance of such adverse circumstances as fatigue, hunger, drought, cold and rain, in predisposing stock to diseases has already been mentioned and these may be sufficient to break down in some cases the additional resistance conferred by inoculation so that in estimating the value of any particular agent they should not be forgotten.

That inoculation of stock should have extended in India during recent years with the rapidity shown by the increasing demand for sera and vaccines, and in spite of the obvious difficulties of securing its voluntary acceptance, is a tribute not only to the value of the agents themselves but also to the energy and perseverance of the Veterinary Department, on whom the task of gaining the confidence of the stock owners rests.

There can be little doubt that as knowledge spreads the importance of guarding their animals against disease will become more widely recognized by Indian stock owners and protective inoculation will-contribute to a still greater extent towards the agricultural prosperity of the country, which depends so largely on the maintenance of the health of its live-stock.

NOTE ON SOIL DENUDATION BY RAINFALL AND DRAINAGE: CONSERVATION OF SOIL MOISTURE.*

BY

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THE question of soil erosion in India in most of its aspects has been discussed recently by the Imperial Economic Botanist, and this note is submitted only because it contains a few observations on the way in which soil erosion is dealt with in a neighbouring country where the problem is of great importance and in many respects similar, and because it may help to identify the agriculture of tea with that of other crops in India in respect of the necessity for improving existing methods of prevention of loss of soil by wash. Although there are many features of tea cultivation which make tea a thing apart from other agricultural operations in India, this is a point where the interests of tea planters are identical with those of other agriculturalists.

The retention of soil on sloping land by prevention of wash is of considerable importance to the tea industry of North-East India not only in Darjeeling, where land slopes very steeply, but in other parts of the tea districts where estates are generally fairly level.

The conditions under which soil erosion takes place in the different tea districts of North-East India may be described as follows:—

In Assam tea land is usually level but it is intersected by *hullas* or *nullahs* (natural depressions which take off surface drainage), some of which are filled with jungle, while rice is grown in others. Tea which has been

* A paper submitted to the Board of Agriculture in India, 1916.

planted for many years on the edges of such *hullas* shows in most cases unmistakable signs of having suffered from the soil erosion which has taken place.

In the Dooars tea land consists of a bank of heavy loam extending several miles from the foot of the Himalayas southwards towards the plains and below this of level land, the soil of which is in most places grey and sandy. There is a definite drop of a hundred feet or more from this red bank to the plain below and similar breaks occur at places in the red bank itself. The tea land of the Dooars is intersected by rivers which flow directly from gorges in the hills, and in time of heavy rain these are rapidly flowing torrents ; in the cold weather they are almost dry. These rivers often alter their line of flow and tea consequently is not usually grown near their banks. In many places near the hills the surface of the stiff red clay loam is undulating. It is on this red bank that the most serious problems of soil erosion have to be faced, and, with a rainfall sometimes as high as 200 inches per annum. and confined chiefly to a few months in the year, the loss by wash is considerable. The fertility of this red soil suffers very seriously when wash has taken place.

In Cachar and Sylhet a particular feature of tea lands is the presence of steep rounded *tilas* (low hills projecting from the level plain) interspersed among flats of different and more recent soil. The *tilas* are sometimes quite sandy. sometimes gravelly, but often of fairly stiff clayey soil. The soil of the flats ranges between a heavy intractable clay and a coarse sand, poor chemically. A special type of such flats are the drained *bheels* (peat bogs) in which the percentage of organic matter may range between 15 and 70 per cent. The prevention of soil erosion is of particular importance in this district in connection with the loss of the fertility of the *tilas*.

In Darjeeling the soil at higher elevations usually consists of a heavy reddish clay and that at the highest elevations is overlaid by a fairly deep humus layer and wash is not

very serious. At medium elevations this clay suffers from wash and the fertility of the land has consequently deteriorated. At medium elevations also some very sandy soils occur and these have suffered very considerably from wash. At lower elevations near rivers where the land is less steeply sloping some rich alluvial sandy stretches are found which have been formed at the expense of the fertility of the ridges and hill sides above.

Throughout the tea districts, with the exception of a few gardens in Darjeeling and on some of the *tilas* in Cachar and Sylhet, the arrangement of tea bushes is in square or triangular alignment and, in solving the problem of protecting estates from loss of fertility by soil erosion, the treatment of considerable areas of old tea, planted in this manner (a most objectionable one on land where serious loss of soil by wash is likely to take place) many years ago, has to be considered, in addition to devising the best means of laying out and planting such slopes on land which is being put under tea for the first time.

At the end of the year 1913 the writer spent some weeks in Java and Sumatra and was much impressed by the means which are taken in these countries to prevent loss of surface soil by wash on tea estates as compared with the efforts made to this end in Ceylon and North-East India.

The whole of the tea districts of Java are sloping land, and it is the invariable custom to plant tea fairly closely on contour lines as distinguished from square or triangular arrangement, the result being that in no cases are there spaces between the bushes in straight lines of any length down slopes such as can be seen on every tea estate in Ceylon and on many estates on sloping ground in North-East India where the planting is in square or triangular alignment. Contour planting is undoubtedly the better method whenever there is possibility of serious erosion.

This being the first step taken by Java planters, other means are adopted according to the nature of the land, and these consist in terracing, where the land is steeply sloping, and in arranging a system of contour drains, contour hedges of suitable leguminous

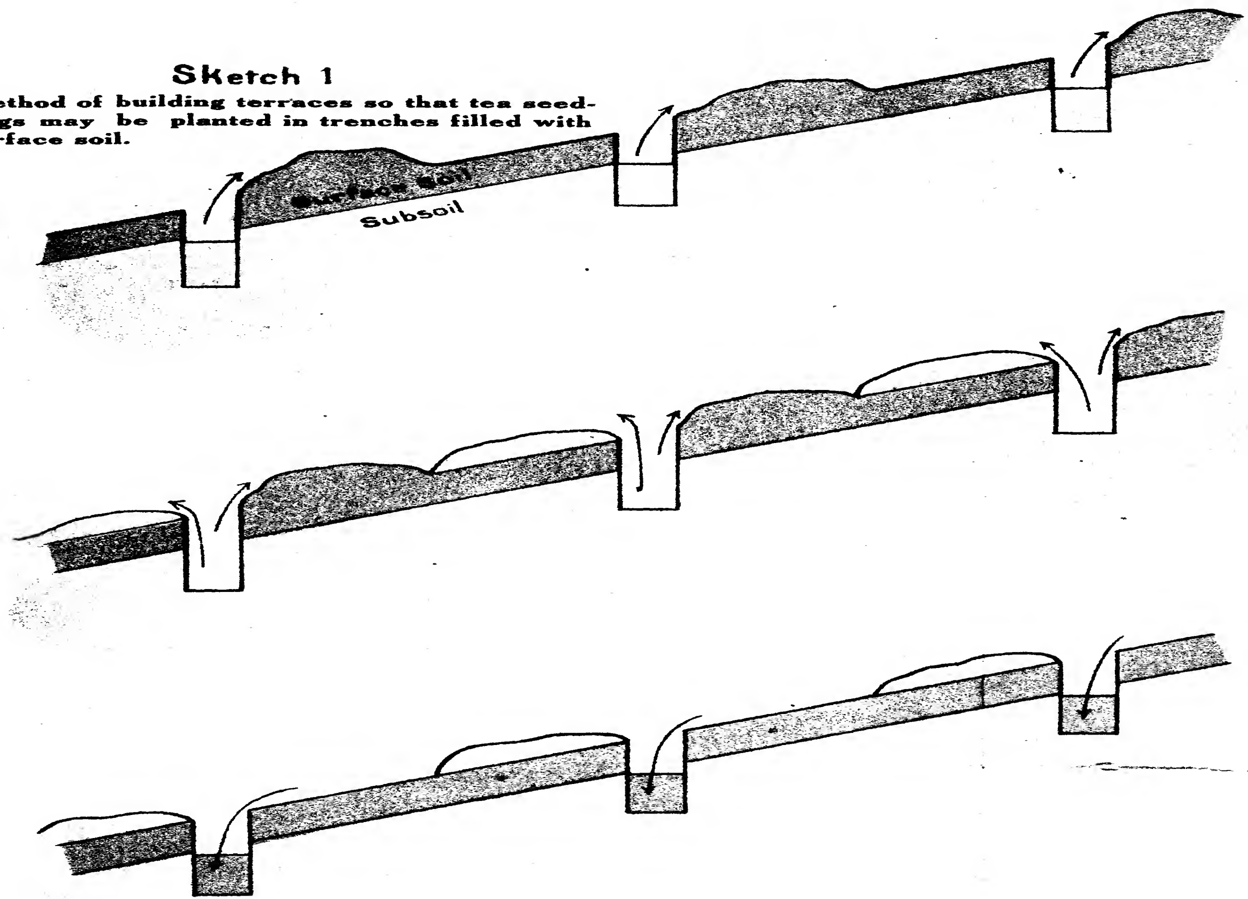
Sketch 1

Method of building terraces so that tea seedlings may be planted in trenches filled with surface soil.

1.

2.

3.



Sketch I Cont.

4

5.

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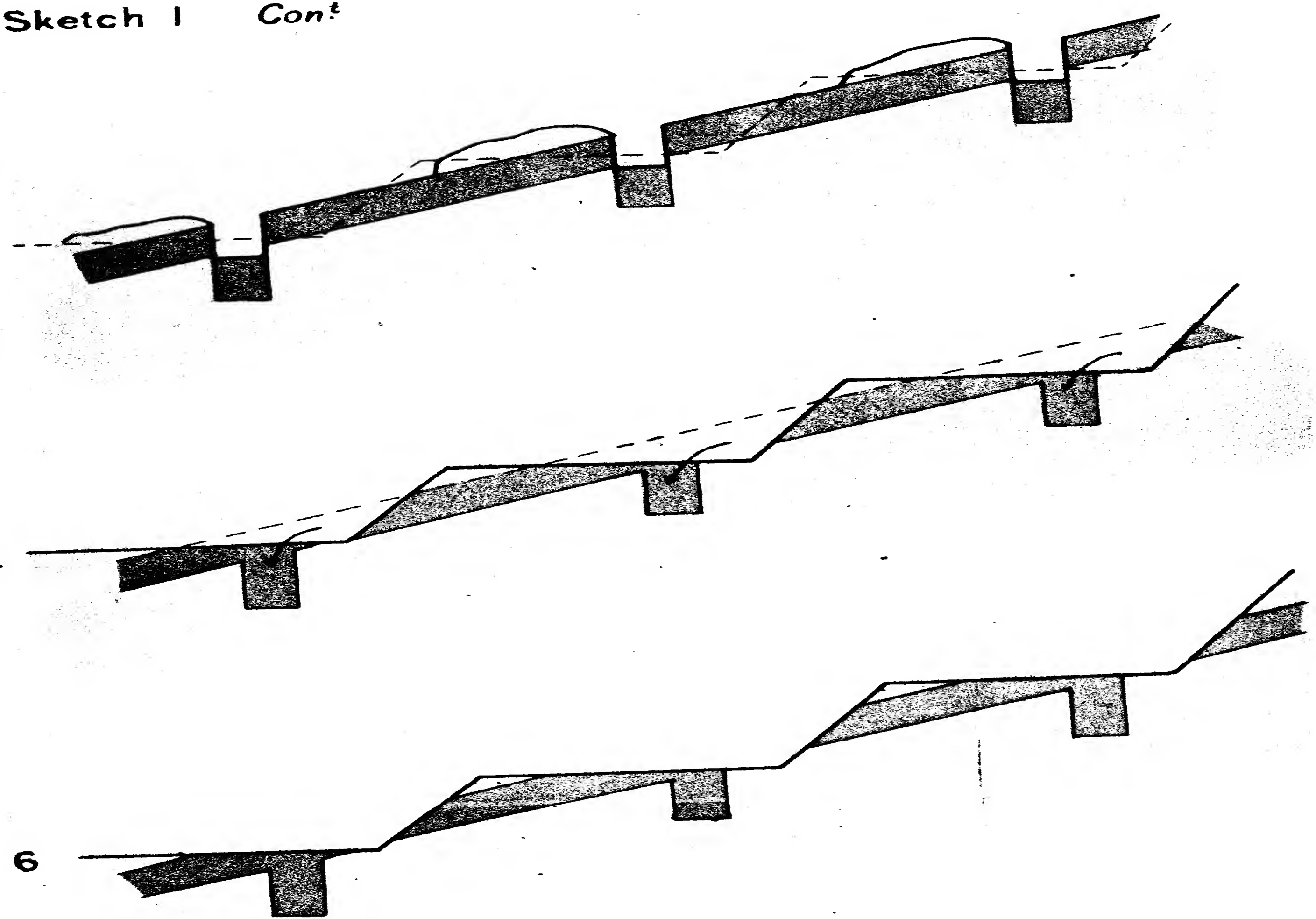
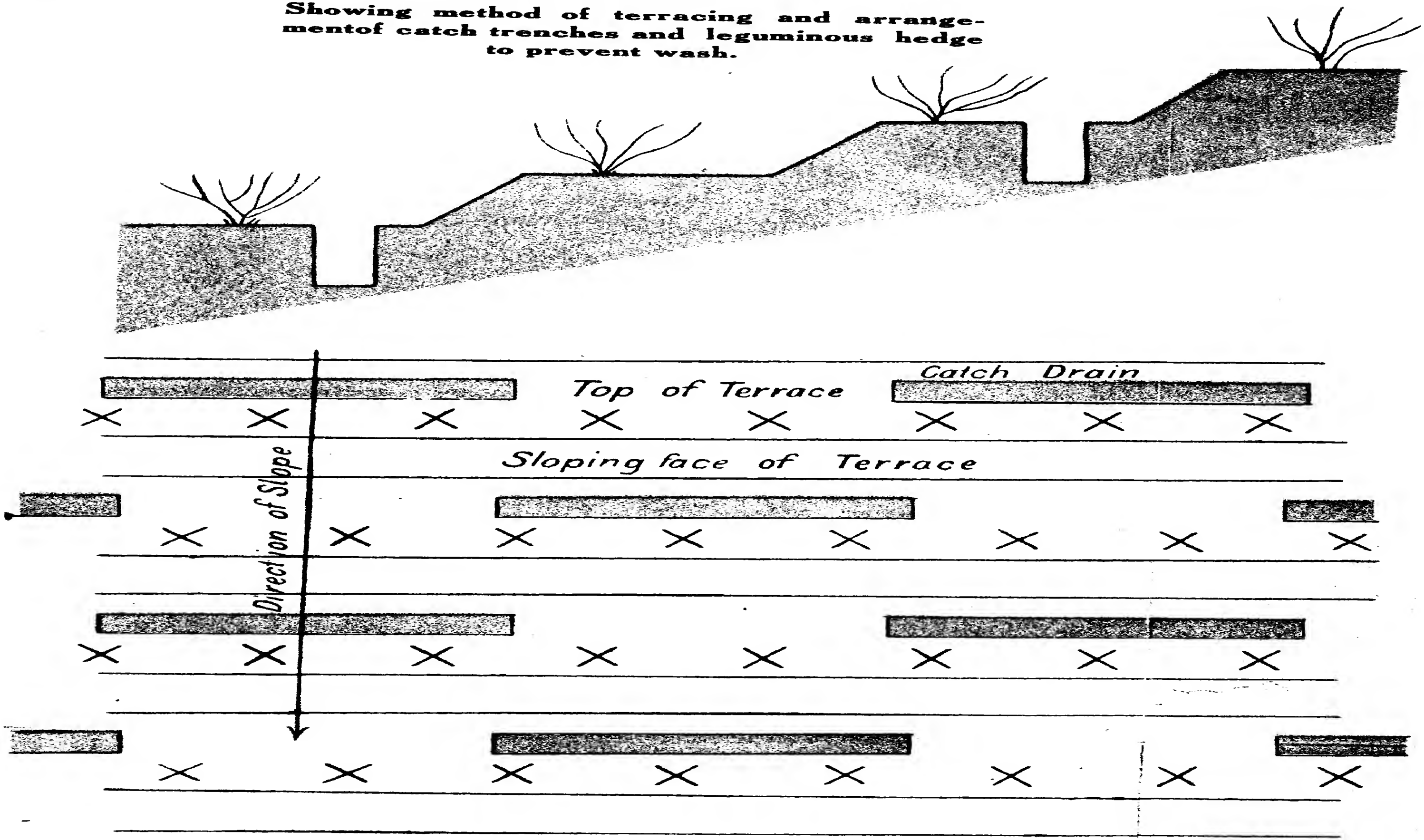


Sketch 2

Plan & Elevation

Showing method of terracing and arrangementof catch trenches and leguminous hedge to prevent wash.



Reference
X = *Tea Bush*

plants, and series of catch-trenches in contour alignment, in less steeply sloping situations.

Opinions differ in different parts of the world as to the value of terraces, a fact which seems to indicate that there may be some factor as yet not fully understood which accounts for terraces being of use in some places while in others their value appears to be doubtful. In Ceylon tea estates terraces are rarely seen in spite of the fact that much of the tea land is more steeply sloping than on most estates in Java. It is surprising that in Ceylon the terracing which is so picturesque a feature of the journey from Colombo to Kandy has not been copied on tea estates and the omission has undoubtedly been an error in judgment though it has been a still greater mistake to have adopted linear instead of contour planting on sloping ground.

In Java, certainly, nearly everyone is persuaded of the value of terraces on steeply sloping ground.

Opinions differ in Java as to whether terraces should be made before the tea is planted or afterwards. The argument in favour of making the terraces before planting the tea is that the work can then be done carefully and completely without any disturbing factors, and, being done, is done once for all, and when the tea is eventually planted it merely remains to adopt an efficient system of keeping terraces in order. Those who are in favour of making the terraces after planting out the tea base their argument on the fact that in such cases the tea is planted in surface—and not in sub-soil, and that if the weeds, when they are gathered, are regularly placed between the rows of tea, planted in contour lines, terraces form of themselves and are in all respects as efficient as those made more expensively before the planting out of the tea. It is possible however to make terraces before the tea is planted out, in such a way that the seedling plants are planted along the lines of trenches which have been filled in entirely with surface soil, and it is more satisfactory from several points of view to make terraces before the seedlings are planted. (Sketch 1.)

Terraces having been made the upkeep of them is a matter of great importance. In Java many different plants are used to protect the edges and faces of terraces and are either planted there directly or, if of naturally occurring species, are encouraged to grow in

preference to other plants by a process of selective weeding of the terrace faces. Species of *Hydrocotyle*, *Viola*, *Desmodium*, etc., are commonly seen grown in this way.

On fairly broad terraces it is often the custom to dig short trenches at intervals along the inner edge of each terrace and these serve to catch the wash which comes from the terrace above. These catch-trenches are cleaned out when the terraces are weeded, and the earth which has collected in them is thrown up on to the terrace above. (Sketch 2.)

The system is an excellent one under Java conditions where weeding and forking, instead of hoeing, is the method of cultivation.

A similar system of catch-trenches is employed largely in cases where the land is not steep enough to terrace. The method then generally adopted is one of alternate contour lines of catch-trenches and of green crops, sometimes with one and sometimes with two lines of tea between them. In such cases the positions of the catch-trenches, which are usually about 12 feet long by 1 foot broad by $1\frac{1}{2}$ feet deep, alternate with 12 feet intervals along the contours, and are arranged in echelon with those next above or below along different trenched contours, so that if any earth is carried beyond one line of catch-trenches and past the intermediate tea bushes and green crop hedge, it will eventually be caught in the next catch-trench below. (Sketch 3.) When these catch-trenches are cleaned out, which is usually done at the time of weeding, the earth is thrown up the slope.

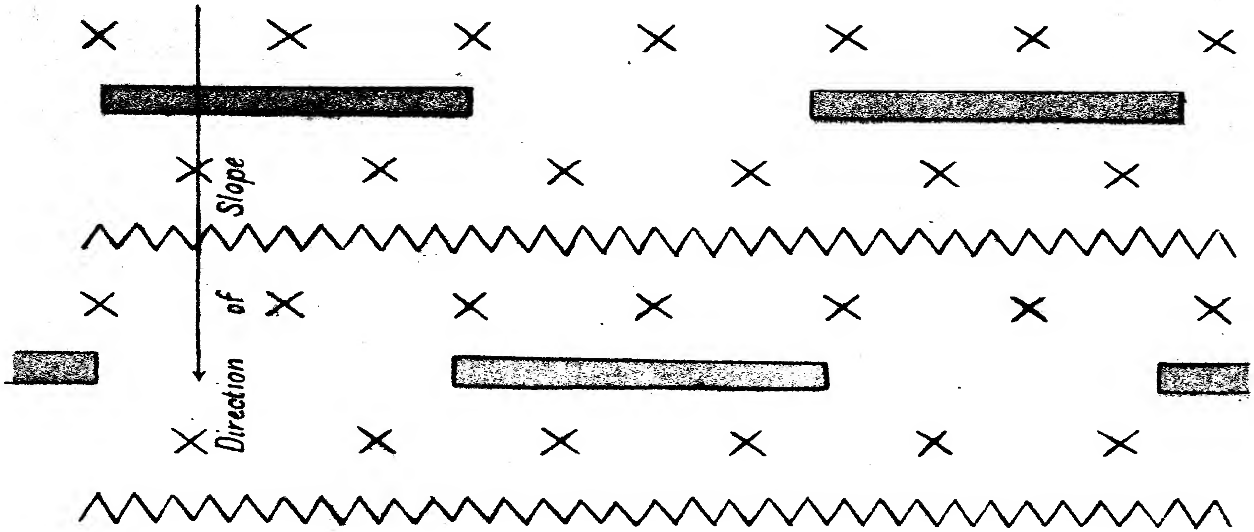
Leguminous plants such as *Leucaena glauca, Clitoria cajanifolia, Tephrosia purpurea,* etc., are the plants most commonly used for the hedges which alternate with the catch-trenches.

Combined with this is a careful system of drainage.

The main drain system—it must be remembered that almost without exception fairly steepy sloping ground is under consideration—consists of "hoeft afvoergoten" (main drains) which lead directly down the slopes. It is considered most important in connection with the drainage system to remove as far as possible the excess water which cannot sink into the ground sufficiently rapidly in case of heavy showers.

Sketch 3 PLAN

Showing arrangement of catch trenches and leguminous hedge on unterraced ground.



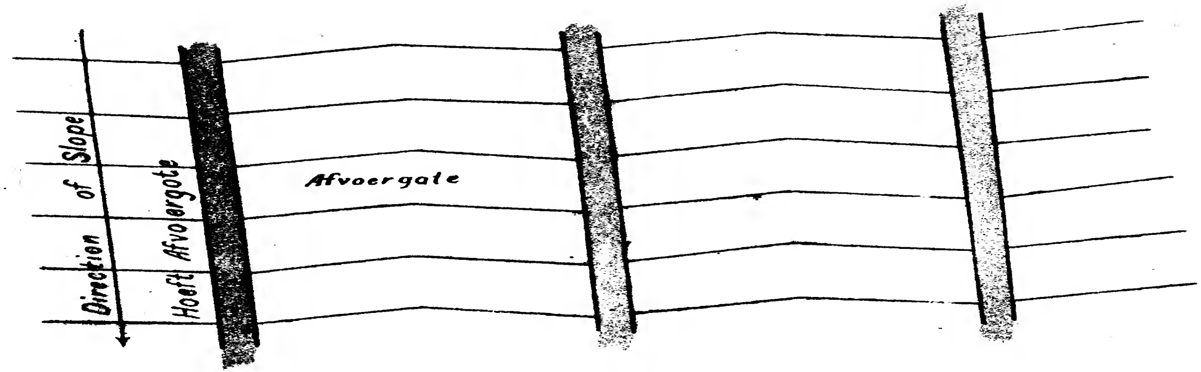
References

X = Tea Bush

ΛΛΛ = Hedge of Leguminous Plant

Sketch 4

Diagrammatic Plan of Drainage of a Slope

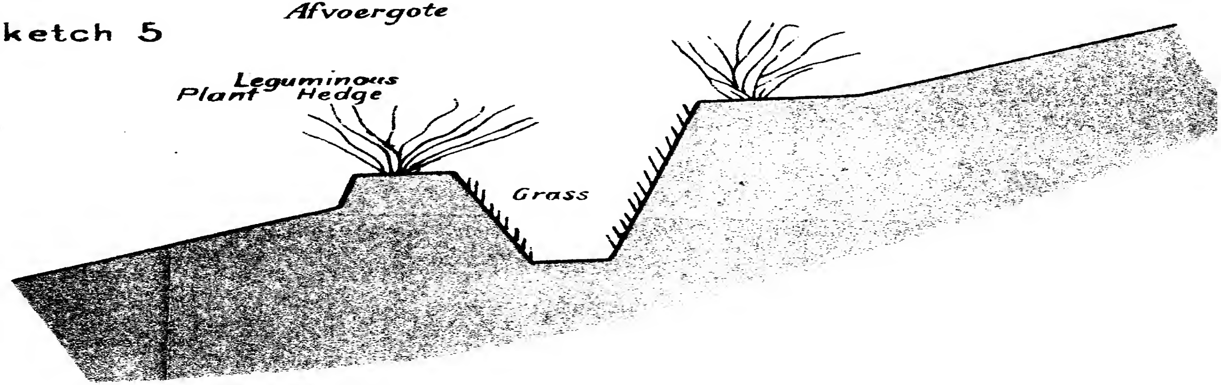


Drainage of a slope.

Elevation

Afvoergote

Sketch 5



The soils of Java are very porous and when slight showers fall the rain sinks rapidly into the ground, but the soil is also very rapidly washed down by water flowing over the surface of the ground, if all the rain water is not immediately removed when heavy rain falls. This is at once the advantage and the danger of the soil of Java.

To prevent this loss by wash, it is considered of primary importance to have an escapement for excess water, and the main drains straight down the slopes serve this purpose best for they ensure the rapid removal of water at places which are chosen for the purpose, and not at places where the rush of water may do damage.

The best situations for some of these drains are the places where there are natural gullies down the concave folds of the hillsides. Where these gullies are pronounced in character one usually finds either rocky ravines, or rather water-logged patches filled with deep rich soil which has been carried there by wash before the opening up of the land. The stone ravines can be used as drains without much being done to them. They are straightened and cleaned out to some extent to facilitate the rapid removal of water. Gullies which are filled with deep earth, when drained, add to the area on which tea can be planted. The sides of these drains are protected by growing grass on them and the rush of water down them is stopped by a series of low barriers of stones, bamboos, etc. A certain number of "hoeft afvoergoten" have also to be made at intermediate positions between the gullies, and the distance between two "hoeft afvoergoten" is usually not more than 100—200 yards.

The collection of the water into these main drains is carried out by means of contour drains called "afvoergoten" and these are usually made with a very slight gradient, the object being merely to catch the water and remove it into the "hoeft afvoergoten" or main drains. These "afvoergoten" are laid out very carefully on Dutch estates in Java, and are flanked on the upper and lower sides by banks on which suitable leguminous plants are grown. Grass is often grown on the sides of the drains themselves. Drains are cleaned out periodically, for the danger of water breaking through must be carefully avoided since it would cause great damage

because it would mean the escapement of water down hill at a point for which preparation for its control had not been made. (Sketches 4 and 5.)

Modifications of one or other of these methods is the system adopted in Java for the prevention of wash, and on some of the new tea estates which are being started in Sumatra.

There is some difference of opinion in Java as to the extent to which cultivation is a factor in aggravating loss of surface soil by wash. Some claim that if soil be cultivated at times of the year when there is much rain, the rain, instead of washing the soil with it down the slopes, sinks into the ground and thus wash would be prevented. Others say that if the soil is undisturbed, and particularly if it be protected with a slight covering of jungle, wash will be inappreciable whereas it will be considerably greater if the soil has been recently cultivated and is broken up and free of jungle growth. Very much depends on the nature of the soil and this is a subject which might receive study in connection with loss of soil by wash in India : that is to say, it would be worth while to determine, in districts where loss of surface soil by wash is known to be great, the effect of cultivation in aggravating or reducing the amount of wash and to correlate this information with data bearing on the mechanical composition and physical properties of the soil.

There is another point which has so far been left out of discussion on the subject of soil denudation in India and that is the extent to which dry wash—that is, movement of particles of soil down hill in dry weather as the effect of wind—takes place. In Java, this dry wash takes place chiefly at medium elevations where the soil is loamy in character but is of sufficiently good tilth to pulverize on the surface in dry weather. The compact soil immediately below the loose layer on the surface affords a comparatively smooth plane down which detached particles of surface soil are blown by wind. These particles collect behind tea bushes and stones and on the flat faces of terraces and are washed down in the form of mud by the first heavy shower of rain.

The extent of the loss of soil which is going on steadily this way in dry weather is undoubtedly very great in some districts of Java,

and it would be interesting to determine whether a similar phenomenon takes place to any great extent in India and in what localities it occurs particularly.

Speaking of tea planting only it may be said that the methods employed in Java appeal to the writer as being unquestionably the best that can be done to prevent loss of surface soil, and although it is a matter of great expense and trouble, yet, where tropical agriculture is becoming yearly more intensive and new land cannot be obtained to replace by new clearances the older parts of existing estates, all that can be done to prevent loss of surface soil on existing estates has a very great commercial value.

The adaptation to the conditions which obtain in the tea planting areas of India, of Java methods should receive careful consideration.

The present measures adopted for the prevention of wash in the tea districts of Ceylon and North-East India appear to be largely wrong or inadequate.

SPRAYING FOR RIPE-ROT OF THE PLANTAIN FRUIT.

BY

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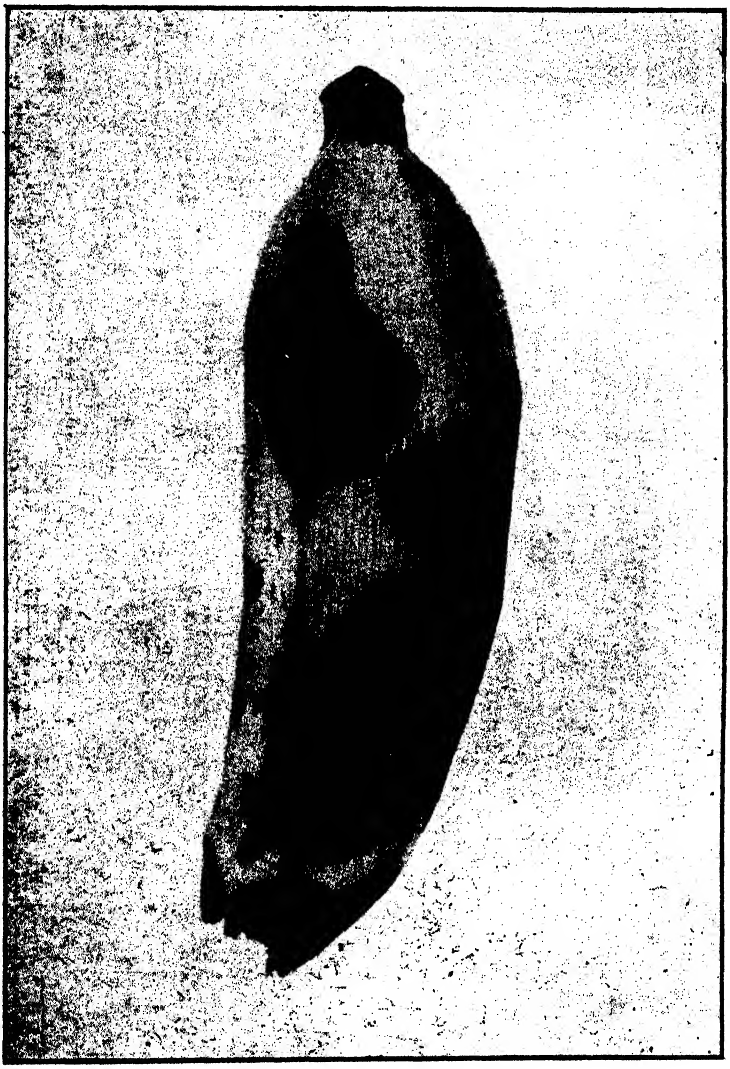
First Assistant to the Imperial Mycologist.

THE plantain fruit is often affected by a ripe-rot caused by a fungus, *Glœosporium musarum,* chiefly during the rains. This disease is common wherever plantains are grown. It is confined to the fruits and the fruit stalk.

In India, as far as the writer is aware, it is chiefly a disease of the stored fruits; but it is also found on very young fruits though fortunately, not often. The presence of the fungus on mature fruits is marked by the appearance of a small black circular speck on the peel. This rapidly increases in size, becomes depressed and in this sunken area are found pink concentric rings which look moist and bright when fresh on account of the presence of oil globules. These concentric rings are the spore beds (" ascervuli ") of the fungus. There are generally more than one such diseased areas which merge into one another and eventually cover the whole fruit. The effect of the disease is to ripen the fruit prematurely and this in its turn accelerates the rot. When the young " fingers " get infected, the infection is generally found to begin from the distal end, possibly arising through the flowers. The infected " finger " begins to turn black and shrivel from the distal end; as the infection progresses the whole " finger " turns black, shrivels, and becomes covered with the pink spore beds of the fungus. The attack rapidly spreads and involves the whole bunch. The fruit stalk also gets diseased but the infection does not spread to the " hands " through the stalk.

This disease is of annual occurrence during the rains. In the absence of the perfect stage of the causal fungus (the perithecial stage containing the ascospores, or winter spores, which has not



A diseased plantain fruit.

yet been found, though this disease has been investigated by so many workers), the question naturally arises how does the fungus ensure its annual occurrence. It has been found in nature to produce

only one kind of spores and they are thin-walled, individually not capable of resisting unfavourable conditions. If the spores are sown in a drop of water they readily germinate in a short time, but if the drop of water in which they are sown is allowed to run dry and after a short time the spores are resown in water, they are found to be dead. On the other hand, if the spores *en masse* are allowed to remain in their ascervuli they have been found to germinate after nine months. The ascervuli, which when fresh are moist and bright pink in colour, become dry and dull light pink after some time;

The fruit bunch on the right was sprayed with Burgundy mixture; the one on the left was not sprayed. Both are of the same age.

they are then found to be covered by a dry crust which keeps the enclosed spores in a compact mass and protects them from unfavourable conditions. When a drop of water is added to this spore mass it breaks away, setting loose the spores which are capable of germination. Diseased parts of the fruit stalk and diseased fruits were kept along with dried plantain leaves in an open basket on the working bench in the laboratory in September. Spores from the diseased parts thus preserved were sown in water in June,

nine months later. The spores germinated, though of course the percentage of germination was not very high. It is probable that in nature also the spores remain thus preserved on the plantation and during the rains the spore masses break up, the spores get disseminated and infect healthy fruits.

This fungus has been found to be a wound parasite, *i.e.*, it attacks the host only through wounds or abrasions on the surface.

Since 1912 this disease has been under study with the object of finding some remedial measures for its prevention. Freshly picked mature green fruits have been dipped in different strengths of copper sulphate, formalin and corrosive sublimate for varying lengths of time without any success. In passing it may be noted that unripe fruits treated with formalin ripened earlier than those of the same bunch treated with other fungicides or the untreated ones kept as controls. Spraying the fruit about two months old once every fortnight till mature with Burgundy mixture or Ammoniacal copper carbonate also failed.

It was soon found that treating the fruits when picked or when half-grown was useless. Fruits picked from bunches which were only half-grown and looked outwardly quite healthy, and which were sterilized by washing them in corrosive sublimate for five minutes gave *Glœosporium* pustules on incubating them under asceptic conditions. The pulp removed asceptically from green and unripe fruits remained sterile on incubation but the peel from the same fruit, sterilized by dipping it in rectified spirit for a minute and then flamming off the spirit, occasionally gave *Glœosporium* pustules when incubated in sterilized moist chambers. These results show that the fruit can be attacked long before it gets ripe and before the disease becomes outwardly visible, but the fungus remains dormant in the peel till suitable conditions arise for developing its activities. Shear and Mrs. Wood,[1] who also have found dormant infections of *Glœosporium* and *Colletotrichum* present in many instances in leaves and fruits showing no external signs of the disease,

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1. Shear, C. L. and Mrs. Wood, A. K.—Studies of Fungus Parasites belonging to the Genus Glomerella. *U. S. Dept. of Agri., Bur. of Plant Industry, Bull. No.* 252, 1913, p. 95.

give a very probable explanation. The conidia germinate whenever they come in contact with the plant surface under favourable conditions and produce appressoria ; these are thick-walled bodies which are capable of enduring more unfavourable conditions than the thin-walled conidia or spores. These appressoria send germ-tubes through the epidermis, in the case of the banana fruits possibly through the wounded surface, as the fungus has been found to be a wound parasite only. The germ-tube apparently penetrates at first but a very short distance, does little harm to the host cell and remains in an inactive condition till favourable conditions for its further development, such as the weakening of the vitality of the fruit or excessive humidity, arise.

As it soon became evident that the fungus infects the fruit even when green, and that, consequently, spraying the fruits long after they had set was useless, and as the disease is most prevalent during the rains, the spraying was done as soon as the " fingers " opened in June, before the rains set in.

On account of the difficulty of procuring pure unslaked lime during the rains, the well-known fungicide, Bordeaux mixture, was not tried, since the application of a badly prepared mixture does more damage to the plant than not applying it at all. In place of Bordeaux mixture, Burgundy mixture (in which lime is replaced by washing soda) was used. Another fungicide that was tried was Ammoniacal copper carbonate. Though this latter checked the disease, still its continued application was found injurious to the fruits. They were sprayed once every fortnight and after the fourth application the spray marks became very prominent. The spray remained lodged where the " fingers " rubbed against each other and here the peel took a sooty brown colour. In cross sections the epidermis and a few layers of the cell underneath it were found to have turned brown, the pulp remaining unaffected. The fruits ripened normally and did not get diseased ; but fruits having these spray marks would be unfit for the market. A solution of half the strength used in the previous case failed to check the disease though it did not injure the fruits. As the other fungicide, Burgundy mixture, gave successful results no further experiments

were made with different strengths of Ammoniacal copper carbonate. Fruit bunches which had just opened all their "hands" or had partly opened them before the rains set in were selected for spraying. This was done once every month till the fruits were ready for picking, except in the case of bunches which were partly opened at the time of the first spraying when the second spraying was done after a fortnight by which time the "hands" were fully opened. In all at the most four applications were given before the fruit bunches were picked. As Burgundy mixture leaves bluish specks on recently sprayed fruits, they would be unpresentable in the Indian market in this state; so when the last spraying was to be done within a fortnight of the picking of the fruits this mixture was replaced by Ammoniacal copper carbonate which keeps the fruits clean. When the fruits were picked they were dipped in Ammoniacal copper carbonate in order to remove completely the Burgundy mixture marks; these marks may also be removed by gently rubbing them with a brush or cloth soaked in Ammoniacal copper carbonate.

Spraying on these lines has been done for the last three years during the rainy season on a very restricted scale but still the results obtained have been very definite and hopeful. The sprayed fruits developed very little *Glœosporium*, and even this little attack was generally found when the fruit had become over-ripe. As a rule the attack was observed to begin from the distal end of the fruit, from the dried remains of the style. Unsprayed fruits kept as controls got diseased, the whole bunch being destroyed, while over-ripe fruits of sprayed bunches showed only a few *Glœosporium* pustules.

It may be here noted that neither Burgundy mixture nor Ammoniacal copper carbonate have been found to check the scab disease of the fruit.

Along with spraying other precautions are necessary for checking the *Glœosporium* disease. When all the "hands" have opened, the fruit stalk should be cut as far back as the last hand, in order not to have any dead part of the fruit stalk where the fungus may live saprophytically. Fruits when picked must be handled very carefully in order not to injure the peel and thereby not to open

a way for the fungus to enter by. Mummied fruit and fruit stalks must be removed and disposed of at a distance from the plantation or preferably burnt. The room where fruits are stored should be occasionally disinfected or whitewashed.

Acknowledgments are due to Babu P. C. Kar, Fieldman to the Imperial Mycologist, for doing the spraying work during the writer's absence from Pusa last monsoon.

APPENDIX.

Preparation of Burgundy mixture.

This mixture is made in the following proportions:—

2 lb. copper sulphate.
2½ ,, of washing soda (carbonate of soda).
10 gallons of water.

Dissolve 2 lb. of copper sulphate in 5 gallons of water. In order to do this suspend the crystals in a piece of gunny bag near the top of the water in a barrel. It will dissolve in a few hours, but if the crystals have been previously ground they will dissolve more quickly.

Dissolve 2½ lb. of washing soda in 5 gallons of water in a separate vessel. Then pour the washing soda solution slowly into copper sulphate solution in the barrel stirring continuously. The mixture should then be ready for use ; before using this mixture it should be ascertained that it is not acid in reaction. If blue litmus paper turns red on dipping it in the solution, add to the mixture in small quantity more washing soda dissolved in water till a fresh piece of paper dipped in the mixture remains blue.

The solutions of copper sulphate and washing soda kept in separate vessels will keep good for several days but once the solutions are mixed, the mixture should be immediately applied, as it deteriorates very rapidly.

Vessels coming in contact with copper sulphate should not be of metal.

Preparation of Ammoniacal copper carbonate.

This solution is made in the following proportions :—

Copper carbonate	..	.. 5 oz.
Strong Ammonia water (B. P.)		.. 3 pints.
Water	.. ..	.. 50 gallons.

Make the copper carbonate into a paste with a little more than one pint of water. Then add the ammonia slowly and stir till all dissolves, except about ¼ oz. or so. If all dissolves add more copper carbonate so as to have an excess. This gives a deep blue clear solution. This can be kept as a stock solution in a well-stoppered bottle. Dilute this stock solution to 50 gallons with water before use.

A NOTE ON THE INHERITANCE OF CERTAIN STEM CHARACTERS IN *SORGHUM.*

BY

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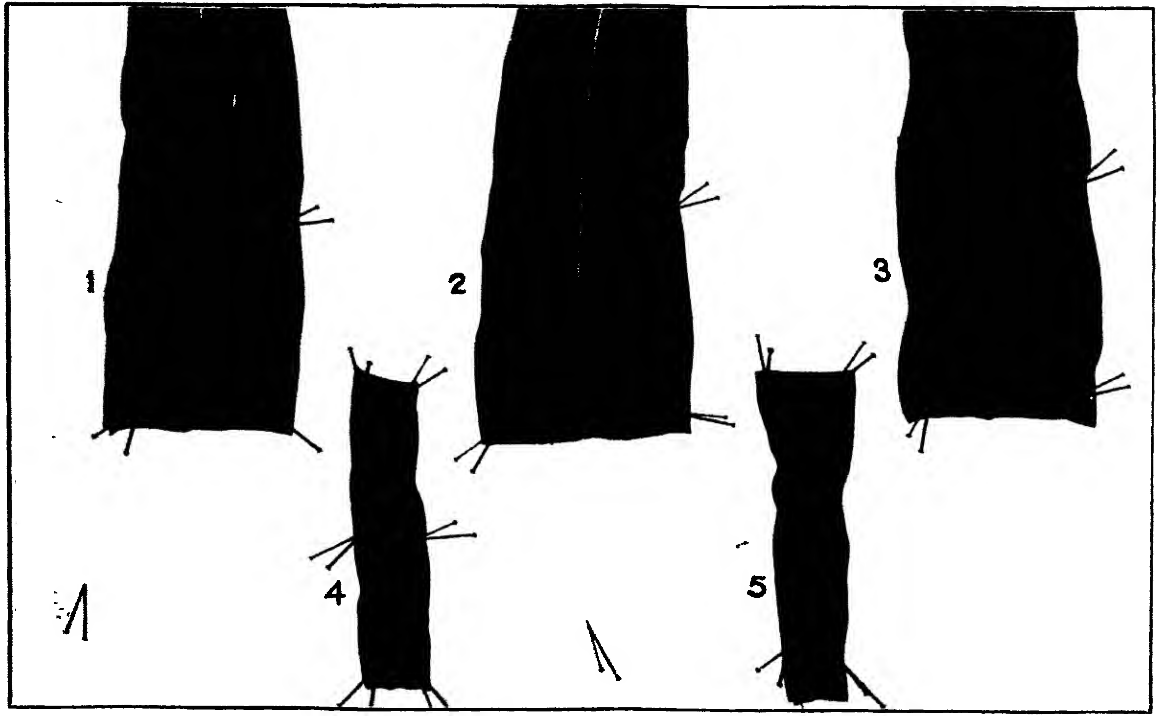
THE information recorded in this note has been gathered in the course of a study, which is still proceeding, of the varieties of *sorghum* cultivated on the black soil lands of Bellary and Kurnool districts, made with a view to producing heavier yielding types of these varieties.

In 1910-11, from which year the writer's connection with this work dates, it was noticed during an examination made at flowering time, of some strains of selected *sorghums* grown at Hagari Agricultural Station, that in each strain the plants could be relegated to one or other of two distinct groups according to the appearance of the mid-rib of the leaf. In one group could be placed all plants in which the mid-rib appeared as an opaque white band running the whole length of the leaf (Plate III, fig. 2). The other group included all plants in which the mid-rib in the lower leaves was marked by a dull white, generally broken band, never extending across the full width of the mid-rib and rarely to the end of the leaf (Plate III, fig. 3) but in the upper leaves was devoid of any white marking whatever. (Plate III, fig. 1.)

Reference has been made to these two types of plants in a Bulletin[1] on the Madras *sorghums* by Benson and Subba Rao in which it is stated that a greyish mid-rib is held to indicate that the stem will be rich in sugar but that a white mid-rib shows that the

[1] Benson and Subba Rao. The Great Millet or Sorghum in Madras. *Bull. Dept. Agri., Madras.*



1. Upper leaf of sweet-stalked plant showing mid-rib without white marking. Plant in shot-blade.
2. Leaf of pithy-stalked plant showing opaque white appearance of the mid-rib. Plant in shot-blade.
3. Lower leaf of sweet-stalked plant showing dull white marking in the mid-rib. Plant in shot-blade.
4. Lower leaf of young pithy stalked plant, showing white marking as a clear white line in the median line of the mid-rib. Height of plant about 18 inches.
5. Lower leaf of young sweet stalked plant, showing dull white marking in the mid-rib. Height of plant 18 inches.

stem will be insipid. A practical test carried out with the plants of the above-mentioned strains proved the correctness of this belief. Whenever the plant examined could be referred to the first group the stem was dry, pithy and practically tasteless, and whenever it belonged to the second group the stem was very sweet and succulent. The test was made by peeling off the outer rind of the stem and chewing the heart. In the following season a further test was made both on the station and outside in the district with exactly similar results. Inquiry among the local cultivators also showed that they were well aware of the relation between the appearance of the mid-rib and the character of the stem and were in the habit of making a practical use of their knowledge when they wanted a little light refreshment in the field but not when they were selecting seed for the next year's crop. Since that time the writer has, while touring in different parts of the Presidency, taken the opportunity whenever possible of testing this relationship and has never been able to record an exception.

In 1913-14 a number of naturally fertilized single plant selections, the character of the stem of which had been recorded at the time of selection, were sown in separate plots at Hagari and Nandyal agricultural stations. When these came to be examined it was found that with two exceptions the progeny of the sweet-stalked parents were all sweet-stalked. The exceptions contained three and four pithy-stalked plants respectively. In one case, a possible, but not probable explanation for the appearance of these pithy-stalked plants was that seed had been transferred from a neighbouring plot by ants, in the other case this explanation was not possible and their occurrence could be due only to cross-fertilization. Similarly, the progeny of the pithy-stalked parents were with two exceptions all pithy-stalked, but in these two the admixture of the foreign type was so great and the position of the plots was such that cross-fertilization afforded the only possible explanation for its presence. Counts were made in these two plots and the following numbers were obtained:—

	Pithy-stalked	Sweet-stalked
At Nandyal	448	153
At Hagari	207	76

These numbers are a close approximation to a three to one ratio and in order to obtain further information a number of plants were selected and the heads were bagged to prevent cross-fertilization. The selection was made as follows :—

(1) Plants of both types from the two impure pithy-stalked strains.

(2) All the pithy-stalked plants found among the progeny of the sweet-stalked parents, and some of the sweet-stalked plants from the same parents.

(3) Sweet-stalked plants and pithy-stalked plants from the plots in which the plants were all of one type.

(4) Also at Hagari a number of plants of both types were selected in some plots of older selections in which both types were found to be present. In this case some of the heads were not bagged.

All of these selections were sown in separate plots in 1914-15 and were examined from time to time during the course of their growth. In the case of the self-fertilized plants it was found that in every case the sweet-stalked parents gave nothing but sweet-stalked progeny, but that while some of the pithy-stalked parents gave nothing but pithy-stalked progeny, others gave plants of both types. Counts were again made in these impure lots and the following numbers were recorded :—

		Pithy-stalked	Sweet-stalked
At Nandyal	1.	190	52
	2.	193	68
	3.	115	41
	4.	157	58
	5.	221	87
	6.	192	74
	7.	183	68
		1,251	448
Ratio approximately		3	1

The season was unfavourable at this station and the plots were thinner than they ought to have been.

Plant No. 1 was one of the three pithy-stalked plants found among the progeny of a sweet-stalked parent. The other two heads failed to set seed.

Plants Nos. 2, 3 and 4 were similarly from the four pithy-stalked plants found among the progeny of a sweet-stalked parent. The fourth head failed to set seed.

Plants 5, 6 and 7 were pithy-stalked, selected from the impure pithy-stalked strain.

		Pithy-stalked	Sweet-stalked
At Hagari	1.	53	14
	2.	39	23
	3.	52	16
	4.	50	23
	5.	36	16
	6.	33	13
	7.	55	9
	8.	46	15
	9.	34	19
	10.	65	26
	11.	56	18
	12.	49	29
	13.	38	21
	14.	76	3
	15.	41	33
		723	278
Ratio approximately		3	1

At this station the season was distinctly adverse, hence the smallness of the numbers and the irregularity in the proportion of plants of each type present in the different plots.

Plants 1, 2 and 3 were pithy-stalked plants selected from the impure pithy-stalked strain. The other plants were the pithy-stalked types selected from the plots of older selections found to be impure.

In the case of the naturally fertilized plants, as was to be expected, both types gave progeny either all of the same type as the parent plant or with some admixture of the foreign type. Out of fifteen naturally fertilized sweet-stalked parents eight gave progeny which contained a few pithy-stalked plants. No counts were made in this series.

Some of the pure strains it was considered worth while to test further for yielding quality and selfed seed was collected from each of them. The plots are again pure this year, containing nothing but sweet-stalked or pithy-stalked plants according to the character of the parent stock.

When making counts in the impure lots it was found that unless the plant had reached the shot-blade stage it was not always possible to refer the plants definitely to one class or the other, but at that stage it was always possible to do so. This difficulty was felt most acutely at Hagari in 1914-15 season when the growth of the plants was poor. The figures quoted for that year and station show the actual numbers of plants which had reached the shot-blade stage at the time of counting, as all other plants were ignored. Examination of the plants of pure strains has therefore been made during the last two years, and the development of the white-marking of the mid-rib has been watched and the following information obtained :—

When the plants are small, that is up to the time when they are about six or seven inches high, no white marking is present in the mid-rib of the leaf and both the sweet- and pithy-stalked plants look alike. Later, the white-marking begins to develop in the lower leaves of both types. In the pithy-stalked types it shows as a distinct white *line* running along the median line of the mid-rib and extending practically to the end of the leaf. (Plate III, fig. 4.) In the sweet-stalked types, the line is dull not so plainly marked, is as a rule broken and does not generally extend further than a little more than half the length of the leaf. (Plate III, fig. 5.) As the plants grow the white-marking develops, much more quickly however in the case of the pithy-stalked plants, until when the plants are in shot-blade, *all* the leaves in the case of the pithy-stalked plants will have white mid-ribs, the white-marking having by that time extended right across the whole width of the mid-rib. In the case of the sweet-stalked plants only the lower leaves will show white-marking which will be in the condition described at the beginning of this paper. Later still, when the grain is beginning to ripen, an increase in the amount of white-marking will be noticed in the case of the sweet-

stalked plants. In most cases the lower leaves will resemble those of the pithy-stalked plants, but a difference is always discernible provided that the leaf has not dried up. The white is not so white and does not occupy the whole width of the mid-rib. The uppermost leaf by this time will also have begun to show some white. No change is discernible in the appearance of the mid-rib of the pithystalked plants after they have reached the shot-blade stage.

To summarize, the results obtained show that—

(1) the character of the green stem in *sorghum*, *i.e.*, whether it is pithy or sweet, can be readily diagnosed from the appearance of the mid-rib of the leaf when the plant is in shot-blade and for some time after;

(2) in breeding tests the pithy character behaves as a simple dominant to the sweet-stalked character.

INDIGENOUS IRRIGATION WORKS IN BIHAR AND THEIR IMPROVEMENT.

BY

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INDIGENOUS irrigation works occur to some extent throughout most of Bihar, but they are found at their best and in greatest number in the Gaya District and in the south of the Patna District, and in this article only these districts will be described.

South Bihar, like other parts of the Province, is liable to suffer from scarcity in years of deficient rainfall, but where this interesting system of irrigation works exists, it constitutes an assurance against serious famine, except in years when the failure of the rains is very bad indeed. And this, notwithstanding the fact that over 52 per cent. of the cultivated area is under rice, and the average rainfall at Patna and Gaya is 44 and 42 inches, respectively. In fact Gaya, where irrigation works are found throughout the district, is practically safe from famine, for though it suffered to some extent during the scarcity of 1866, in that of 1874 it only received a small measure of relief, given more as a precautionary measure than as a necessity, while in the famine of 1897 no relief was required. In the district of Muzafferpur in North Bihar, on the other hand, where the soil is very retentive of moisture, but irrigation facilities do not exist, the suffering was much greater in each of these famines, and necessitated considerable outlay on relief.

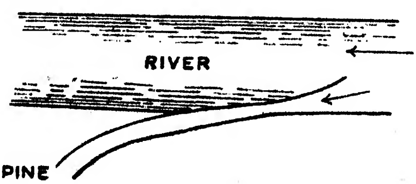
The two districts, Patna and Gaya, are adjacent, Gaya being immediately south of Patna. They are bounded on the north by the Ganges, which separates them from North Bihar, on the west by

the Sone river, on the east by the Bhagalpur Division, and on the south by the mountainous Chota Nagpore Division. The physical aspects of the tract must be studied in order to understand the system of irrigation works. First, in the north a narrow, but varying strip of low land is met with, known as the *diara*, running right across from east to west along the edge of the Ganges. This is usually flooded in the rains, but grows excellent crops at other times. South of this there is a bank of high land, which also runs from east to west roughly parallel to the river. It is along this high land that the East Indian Railway main line has been constructed. Continuing south the land falls sharply into a depression, which slopes from west to east, and is of greatest area in the Barh or north-eastern subdivision. This belt of very low-lying land varies in depth from three or four to about fifteen miles. Once across this the land begins to rise as one proceeds south, at first very slowly, then more rapidly. In the Northern or Patna District the rise, though steady, is almost imperceptible, the general appearance being a vast alluvial plain, broken by villages, mango groves, and lines of palm trees, with hills perhaps visible to the south. After crossing into the Gaya District the same appearance is presented by the Jahanabad subdivision, except that now solitary hills can be seen dotted about to the south. On leaving the Jahanabad or Bihar subdivision the plain begins to rise more rapidly, small isolated conical hills, covered with jungle scrub except where there is bare steep rock, break through its surface here and there, and a line of low hills runs north-east starting near Gaya town. Gradually the land climbs up, until, near the southern boundary, it meets, and is cut into by, the spurs of the Chota Nagpore hills, the lower ranges of which stretch right along the southern end of the district, wild, rocky, and covered with forest, jungle, or scrub.

Across this sloping plain, from south to north, run numerous parallel streams which rise in the southern hills. Flowing at first nearly due north they afterwards bend to the north-east, and then to the east. This easterly course is taken when they have reached the low depression lying south of the Ganges, and the land of that area is subject to more or less serious floods nearly every rains

when the rivers overtop their banks and spread across country, almost at will. Only one river, the Poonpoon, succeeds in forcing its way through the high bank bordering the Ganges, the others turn to the east, flooding out into marsh or *jhil*, until they eventually find their way into the Ganges lower down and outside this division. In the hot weather, and even earlier, in the cold weather in some cases, the river beds are nearly all mere dried up sandy tracks, but in the rains they fill rapidly and carry down a considerable volume of water.

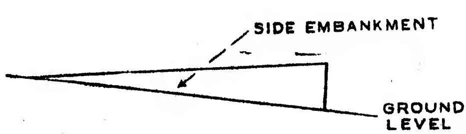
It is over this plain, which slopes from south-west to north-east, and is cut up by numerous rivers, that a network of private irrigation works has been constructed. The area is characterized by a scanty rainfall and a rapid slope, four to six feet per mile in the southern Gaya District, off which the water quickly runs, while the soil, which is usually either stiff clay or loose sand, is not very retentive of moisture. Rice can only be grown, therefore, by impounding and using every drop of water that can be got. This is done in two ways, first by long, narrow canals called *pines* which open out of the rivers and lead the water from them to the fields on either side; and secondly, by catchment basins (called *ahars*) which hold up and impound the water behind embankments built across the line of drainage.



Diagrammatic plan of river and pine.

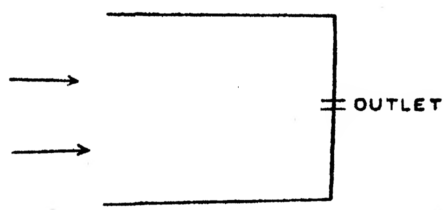
The *pines* lead off from the rivers at an angle in such a way that the water flows down them to fields at a lower level. Thus if a river is flowing north, the *pines* will stretch out north-east and north-west from it, like twigs from a stem. The mouth of the *pine* faces up stream and a bund runs out into the river bed to turn the water into the canal. These bunds are frequently of masonry, and may be continued across the river's bed as the volume of water

decreases. The lengths of the *pines* vary considerably. Some of them are merely rough ditches stretching for a mile or so, many of them are five to ten or even twenty miles long with numerous branches (*bokla*). One, near the Patna-Gaya boundary, is said to be 80 miles long, including all its branches; and it would appear that their number and length is much greater than is suspected, even by those who know the country well. As they vary in size and length, so do they in general appearance. Some are fed by rough irregular bunds scratched up in the river bed, others have well made embankments for this purpose, which are often built of masonry. Some contain pukka sluice gates, and many branches, with brickwork openings to let the water into the fields. Frequently they travel for considerable distances embanked above the level of the surrounding country, gradually sinking until they are below the level of the fields on either side. In short, they are adapted in numerous ways to the various needs for which they are built, and the natural characters of the country which they serve. One large *pine* near Gaya, for example, flows for two miles into a depression used as a lake, the water in which is increased by the drainage of a considerable area, and the rain water that washes down from a hill that borders it on one side. The lake is partly enclosed by an embankment across its lower end, in which are large masonry sluice gates, opening into another *pine* that takes the water for a further twelve or thirteen miles. When a *pine* or *bokla* is above the level of the land the water is run into the rice fields by small distributary channels, but when it is too low to flow out in this way it is raised by lifts. The *pines* may discharge their surplus water into another river bed, or into a *jhil;* but in the majority of cases they either run into an *ahar*, or simply end in small channels, so that all the water is used upon the fields.



Diagrammatic plan and side view of an *ahar*.

Between the rivers from which the *pines* lead off the land rises from either side to the watershed, and it is on this higher land that *ahars*, the second form of local irrigation works, are chiefly found. They also exist, however, interspersed among the *pines* themselves. An *ahar* is a catchment basin, usually more or less rectangular in shape, formed by building an embankment across the drainage line, with two sides running up the slope, that is, in this district, where the land slopes nearly always to the north, a bund is built from east to west, and from its ends two other bunds are taken south, which gradually decrease in size as the level of the ground rises. Some of them are built to catch the surface water only, others are built across a drainage rivulet. In all cases there is an outlet at the lowest point, where the water would ordinarily flow if no embankment had been made. If the water flows in from a rivulet or *pine* there is usually a weir in the northern bank; this may be topped by a *tar*-tree stem, but is frequently made of masonry. The water flowing out of one *ahar* often passes on only shortly to be caught in others.



As in the case of *pines*, *ahars* vary considerably in size and general appearance. Some are very large indeed, with masonry weirs and numerous sluice gates to let out the water for irrigation; others discharge their water through pipes made of hollowed *tar*-trees, in others again, and these are mostly small, the bank is simply cut.

The people are fully conscious of the advantages of these irrigation works, and have evolved a system which should tend to keep them in repair, and to increase the number built. It is obvious that the *raiyats* could not, and would not, construct such works, nor could they keep them in repair when they exist, as they have

not got the necessary capital, nor are they likely to combine in sufficient numbers. It is necessary, therefore, that the zamindars, or landlords, should take the matter up. The general opinion evidently was that in order to make them do this, the prospect of an increased rent would not be sufficient, and it was so arranged that the amount of rent depended entirely upon the extent to which facilities for irrigation were provided. This is done by letting out the irrigated lands for the most part, on produce rent (*bhaoli*) whereby the landlord receives a little more than half the crop. The crop is appraised in the field before it is reaped, and the value of the landlord's share is paid by the tenant, either in cash or in grain. The *bhaoli* system is found scattered here and there in all parts of Bihar, but as the *raiyats* much prefer to pay fixed cash rents (*nagdi*), produce rents occur as a rule only when there is some special reason, as in this case, for the system gives the landlord excessive power over his tenants. We find, therefore, that about 70 to 75 per cent. of the rents in Gaya, and about $\frac{2}{3}$rds of the rents in the Bihar subdivision of Patna are paid on the *bhaoli* system. In the Saran District, on the other hand, where there is little irrigation the proportion is only about 5 per cent. Construction works and big repairs are undertaken by the landlords with men hired for the purpose; but small annual repairs and petty works, such as clearing silt from *pines*, closing small breaches, and repairing the lesser distributary channels, are carried out by the tenants on the *goam* plan, that is, one adult of every family benefited by the particular irrigation work concerned is called out to do the work, for which he usually receives no remuneration either in cash or kind.

An elaborate set of rules for the distribution of water has been drawn up in the course of time by custom and mutual agreement. These settle where, and for how long, bunds may be built to turn the water; which distributaries may be opened first when more than one are wanted, and the time they may be used; the length of time each village, or each block in a village, may receive the supply, and other similar questions.

From the details given above a picture of an ideal irrigated tract can easily be imagined. The landlords, singly and in

combination, build *pines* and *ahars* in every useful spot, keeping them in thorough working order. By their power and prestige they aid public opinion in enforcing the laws governing the supply in turn. The tenants willingly carry out the work of repairs for wages when the work is large, but without when it is small. Cultivation is careful and intensive, and the outturns large, thus benefiting both raiyat and zamindar.

The reality, unfortunately, is not like this. Practice falls short of theory for many reasons, some of which have more effect in one place, others in the next. First among them is the gradual division of property, the parcelment of large holdings that has been encouraged by a settled rule. Where formerly there was but a single zamindar, there are now perhaps fifty petty landlords, whose interests conflict, or whose relations are so strained that they will not combine. The result is that no new works of any size are undertaken, these works having been carried out as a rule in the past by one man who owned the whole area to be irrigated. More than this, such large works as do exist are falling rapidly into disrepair, owing both to lack of means on the part of the numerous smaller men who own them now, and to their mutual jealousies. A case of this is very evident near Warisaliganj in Gaya. Here some twelve or more years ago the Sakri river turned into the channel of one of its *pines*, with the result that the supply of water for the canals further down has gradually been cut off, while the original *pine* has been enlarged into a river bed blotting out a large culturable area. Various landlords are concerned, many of whom are willing to combine, but, as others still refuse, nothing is done, owing to a natural disinclination on the part of those willing to do their share to incur expense for the benefit of those who will not join. Again, the Holya *pine* which passes through the village of Chandragarh in the west of Gaya, could irrigate much more land than it now supplies, but the zamindars of Chandragarh will not allow the water to be used by others because their ancestors incurred the expense of building the canal. The surplus water, therefore, runs to waste. Examples more or less like these are common. All this results in full use not being made of the present *pines*, and no increase of the irrigated area.

A second cause is lack of engineering knowledge and experience. On the whole, the engineering ability displayed is large, but if the works were under expert care very much more could certainly be made of them. The unfortunate mishap at Warisaliganj described above is not unknown elsewhere, but such would not occur if an engineer were to direct the work.

Thirdly, the tenants themselves do not make the best of their opportunities. The fact that more than half the produce goes in rent leads to slovenly cultivation. Nearly every raiyat has some *nagdi* land besides that which he holds on *bhaoli*, and all his spare time and extra care are spent on cultivating the former, the latter getting much less thorough work.

Fourthly, disputes about precedence in receiving water are frequent, both among people served by the same *pine* and between villagers of areas lower down with those above them who may have dammed a river to turn the scanty flow. Riots constantly occur in years of deficient rainfall, and especially when the *hathia* rains fail. So numerous are these disputes and riots that more than five per cent. of the time of the District Judge is taken up by irrigation cases.

Nevertheless, in spite of its shortcomings, there is no doubt that the indigenous system of irrigation described above is indispensable. The exact amount of benefit derived from it is difficult to gauge, but it is very great, and without it certain parts of the country would be an uncultivated waste. Its usefulness of necessity varies from year to year with the varying rainfall. The manager of a large estate estimated that over a number of years the rice on the irrigated tract is double that on the other land, and in bad years the rice on the unirrigated area is *nil*. Even this is no exact description of its value, for in many cases irrigation facilities have been provided for those lands on an estate most in need of them, the unirrigated fields being those that can most easily do without.

Allowing then that the scheme is a good one, and that it adds largely to the general prosperity of the people, and saves the area from famine, the question how to improve and extend upon it is one of the greatest importance. The question is not a simple one,

as a little consideration will show, nevertheless it should be faced, and in the writer's opinion it is one about which the Provincial Agricultural Department should interest itself peculiarly. This view is not universally accepted, for it is sometimes objected that the matter is too big and any way one that concerns legislators only. But nothing should be too big for the Agricultural Department or outside its province that is connected with agriculture and the welfare of the agricultural classes.

The improvement of existing conditions has already occupied the attention of the authorities, and a Bill was under discussion in Bengal but was dropped when Bihar and Orissa was formed as the subject concerned that province. The chief points of the Bill as proposed may be summarized as follows :—(1) The Collector can direct and compel fulfilment of a record of rights in respect of the use of water and repair of the means for securing a supply of water. (2) The Collector may, if he thinks fit, direct the construction of any sluice, weir, or other work necessary to regulate the supply of water in accordance with any rights recorded in a record of rights. (3) Any person desiring the construction of a new irrigation work may apply to the Collector if he cannot acquire from its owners the land needed; and the Collector, if he thinks the new irrigation work expedient, and if any objections on the part of any other people do not appear to him valid, can enforce the transfer of the land necessary, and settle the amount to be paid for the land. (4) In the same way if any one desires the transfer of any irrigation work from its present owner to himself, the Collector, if he thinks the said transfer is necessary for the better management of the irrigation from such irrigation work, can enforce the transfer and settle the compensation due. (5) Where in any area the rent is on the *bhaoli* system, or has been fixed or enhanced in consideration of irrigation facilities, or irrigated for 20 years, or irrigation works have been carried out under sections 4 and 5 above, and the irrigation works are out of repair, the Collector can cause them to be repaired. (6) No person can make a dam across any irrigation work unless he has the right to do so, and if he does, the Collector may remove it.

In discussing the Bill as here proposed the writer does so as an agriculturist, and without the least pretence to what, perhaps, may be called the legal knowledge necessary, and his definition of legal knowledge would probably include many matters a lawyer would not include. This must be plainly understood both in respect to the criticisms and suggestions. It is quite possible that the latter may be impracticable for reasons outside the writer's view, and for that reason they are put forward very tentatively.

Provided that the subject is approached on the lines of the Bill little more can be done than has been done, and sections 1, 2 and 5 above will result in a great improvement in existing works. That such an improvement is necessary is shown by reports which were called for from all the areas concerned, and which gave numerous instances of works that had fallen into disrepair. The most common cause given for this neglect in repairing the works was the difficulty of co-operation that arises in estates held by numerous co-sharers, and among several zamindars. Another cause given was poverty. And another, though not so common as the above, a desire to oppress the tenants, particularly in cases where the *raiyats* wish their rents to be fixed payments in cash. If, however, we turn to the ways in which the actual falls short of the ideal given above, it is at once apparent that the Bill does not remove several of the disadvantages there set forth. It does not provide adequate means for the increase of the area under irrigation, it does not help the abolition of the *bhaoli* system, and it gives only a partial insurance against engineering mistakes.

With regard to the necessity of providing for an increase of the area irrigated. In a few tracts the irrigation works are complete, but in large areas they are not. It is impossible to estimate accurately the extent of land which might be, but at present is not, irrigated; to do so would require a survey by an engineer and an agriculturist. There is no doubt, however, that this area is large. The eastern portion of the Aurangabad subdivision is said to be capable of considerable improvement in this respect. In the Jehanabad subdivision, and the south of the Patna District a lot of water runs to waste; and it has been estimated that three-quarters of the

former tract could be irrigated if proper works were erected. To give two specific examples, the District Board Engineer has reported that in one group of villages in the west of Gaya whose area is 14,168 bighas, 3,472 bighas are irrigated by *pines* and *ahars*, the remaining 10,696 bighas could be irrigated if the existing *pine* were repaired and enlarged. He has also reported that in Kutumba perganah out of 121,018 bighas, of which 18,692 are irrigated, a further 41,817 bighas could be irrigated if the *pines* were put in order and enlarged. These last two examples are not exceptional. They apply, of course, only in part to the construction of new works, and include repairs such as the Bill will introduce. Section 3 of the Bill does not meet this difficulty of increasing the area sufficiently, the method of procedure in applying to the Collector may deter some would-be applicants, and at best it only provides facilities for men able to pay for the erection of the works.

With regard to the advisability of abolishing the *bhaoli* system of rent. This system, in the majority of cases, is bad, and it only exists to the large extent found in this part of the Province because of the irrigation works. A former Collector of Gaya has reported "The system is advantageous to a powerful and unscrupulous landlord, as against a poor and weak tenantry and keeps up, or fosters the existence of, so many middle men and encourages so much dispute, peculation, and dishonesty on all sides as to stamp it unmistakably as bad.... It is the fact that it favoured the rich and powerful that has caused it to maintain its position so long." Under the *nagdi* system the tenant puts better work into his land, and is almost invariably more prosperous. While the matter is under consideration it would be a very good thing if the abolition or reduction of the *bhaoli* system were kept in view.

If the whole matter could be approached from another angle, might it not be possible to avoid the three objections given above? The erection of efficient irrigation works is very profitable; they have on occasions even paid for themselves by the extra rent in the first year. Now would it not be possible for Government to take over the repair and extension of the works itself, making the users pay? A tax might be levied on both landlord and tenant, and

the proceeds used for carrying out repairs, either under engineers on a par with the District Board Engineer, or preferably under the Public Works Irrigation branch. The same organization that kept up the existing works might be used to look out for places where new works are required, in conjunction to some extent with the Agricultural Department. New works could be erected on borrowed capital, the rates levied being used to pay back the capital with interest in a certain number of years.

Further, co-ordinated superintendence by a qualified engineer would result in an approximation to the ideal that no available water should be wasted. It is not suggested that such supervision could provide sufficient water for a maximum crop in scanty years, but it would prevent the loss that at present occurs. Another point also these experts might consider is the suggestion that artesian wells can be bored in Gaya.

Some such system as this would get over the difficulty of the extension of these works and the lack of engineering knowledge, while it would certainly cause a gradual change in rents from *bhaoli* to *nagdi*. There are, of course, difficulties which are at once apparent, but most of them are 'legal' difficulties, which in this article are taboo.

CATTLE BREEDING, WITH SPECIAL REFERENCE TO THE MILCH COW.*

BY

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At the last year's Conference of the Co-operative Credit Societies held at Benares I had the pleasure of reading a paper dealing with that most important subject, *viz.*, the improvement of the Indian cattle. I then described the disadvantages which we suffered in this country, and the difficulties which we had to surmount. It was pointed out that the question of grazing lands had first to be dealt with, and I think I mentioned that where insufficient pastures existed, it would be necessary to take some steps to provide for the deficiency in grazing by giving more attention to the economics of feeding by other methods, and by the use of such foodstuffs as could be cultivated, purchased, or otherwise procured. Steps have already been taken in this direction. The reclamation of ravine lands for grass has been undertaken and at the same time the question of the opening of forest areas for grazing is being given due consideration. In those tracts where grazing is very limited small holders are being encouraged to reserve a small portion of their land for the growing of fodder crops, and the use of many valuable foodstuffs, such as cotton cake, is being widely introduced. So much then for the question of feeding.

We next discussed the necessity for an adequate supply of breeding bulls. To meet this demand two Government farms have

* A paper read at the Provincial Co-operative Conference held at Lucknow in February 1916.

now been established and are commencing to issue on loan bulls of the best varieties which are considered suitable for the various tracts of the province. The Hissar, Kosi, and Sahniwal (Montgomery) strains are being maintained for the western districts and for those herds where milk production is the primary object. For those tracts in Oudh where small but sturdy plough cattle are required the Kherigarh, Parehar, and Ponwar breeds are recommended and are being issued.

Buffaloes of good milk yielding strains are now bred; and bulls of this description will also be distributed. Government has sanctioned the giving of advances for the purchase of good cows in those parts where an improved type seems desirable, and suggestions have been circulated for the proper care and management of breeding stock, and the rearing of young calves. In order to encourage intelligent selection in regard to the mating of the cattle, a scheme is being drawn up for the local award of prizes for the best specimens of calves bred by the owners of cows, and got by the Government bulls. Due notice will be given of the dates from which these awards will commence in order to allow intending breeders sufficient time for the selection of cows for breeding of the young stock.

So far then as much as can be accomplished for the present has been done, but even the improvement of grazing grounds, the distribution of bulls and improvements in other directions which I have mentioned, will not be sufficient to produce any very marked advance until more personal and intelligent interest in the matter of breeding and general management is shown by the breeders themselves. I regret to say that except in a very few cases insufficient attention is paid to the fundamental principles of breeding. The breeder's aim is often only to obtain a calf, and for this purpose he will have his cow covered by the nearest bull without bothering as to what it is likely to turn out and without regard to the quality of the sire, or the suitability of the union. Cows are frequently allowed to mate with undersized, immature, ill-shapen mongrels, and still more often with old and decrepit animals. In many cases cows of an essentially small breed are provided with an unnecessarily large and unsuitable bull, the product generally being an

awkward, unwieldy bullock, totally unsuitable for the tract it is to work in. On the other hand, good milk cows of large size are frequently allowed to be covered by small indifferent bulls of a poor milk giving variety.

The inferiority and unsuitability of many of the bulls in this province may be responsible in a great measure for many barren cows; nevertheless, it is the want of attention and care at the time of mating that has been the cause of considerable loss, on account of cows failing to conceive, which otherwise should have produced good calves. The financial aspect of cattle breeding does not receive sufficient attention from the breeder. It may be said of stock rearing as of other matters that time means money, and by breeding regularly from a cow and utilizing the services of a suitable bull, a much greater return for that cow's value will be obtained in the number of calves produced and the amount of milk yielded.

My remarks of course generally apply to all classes of cattle and buffaloes, but I would here like to take the opportunity of saying a few words regarding cattle breeding as it specially affects milk production. It is not proposed to discuss the question from an entirely commercial aspect nor from the point of view of the *gowala.* I shall confine myself to the subject more as it affects the private owner who wishes to keep good cows for milk for his family or those persons who are interested in breeding improved dairy cattle. As you all probably know, the sole object of the professional *gowala* is to obtain milk. He is not usually particular as to its quality or cleanliness, provided he can obtain a sufficient quantity daily to keep his trade going and bring him a more or less regular living. This usually leads to the frequent as well as wasteful practice of milking a cow until she has become dry, and then selling her barren for whatever little she will fetch. I am sorry to say there are many cows wasted yearly in this way which would otherwise have continued to fulfil a useful purpose as breeders and milk producers. The reason of this practice is probably to be found in the want of facilities for maintaining cows between the period of their ceasing to milk and the birth of the new calf. It is thought that dry cows are a trouble and expense to keep, but unless the animal is an inferior

one a cow will amply repay her owner if proper arrangements are made to provide for her in the meantime. It is here that co-operation would be most effective by enabling arrangements to be made for cheap grazing, maintenance, and attendance, for dry cows and those in calf. With the private owner, however, no difficulty should arise in this respect, and he will find it to pay better to continue breeding from his cows if they are good than to milk them out and sell them barren. A cow usually may be covered when her calf is four to five months old and this should always be done. As pregnancy advances the milk supply will gradually decrease but this is compensated for by having to maintain the cow when dry only for a short period.

For family purposes or where two or three owners can work together, the following plan has been recommended. To begin with, one cow in full milk should be purchased, and five months later, another one also in full milk. After a further five months a third cow in the same way may be added to the herd. Now, if a cow give 10 seers daily she will, when in full milk, most likely average 7 seers daily for nine months and with proper care she should give a calf about every 14 or 15 months. Therefore, when the first cow is half through her time of milking and the yield is commencing to decrease the second cow will be in full milk and by the time the first one actually stops milking the third is commencing to give its supply. Thus by the time the second one stops, and the third is half through her time and her milk beginning to diminish, the first cow will calf again and will recommence to give her yield. By this method if they are good cows they can all be retained and will pay their way. The financial return of such a system can be easily worked out and after deducting expenses for feed and keep from the value of milk and calves produced it will be found to be a paying transaction. I would here like to impress the fact that inferior cows are under any circumstances a bad investment. It is well known that it costs practically as much to maintain a bad animal as it does a good one. Old cows should never be purchased; it is better to buy an animal giving her second or third calf. Buyers are often deterred by high prices and sacrifice quality to economy. If, for example, a cow gives an average

of 7 seers daily the value of its produce at 8 seers to the rupee is 14 annas daily. If the cost of its up-keep be 8 annas the net daily profit is 6 annas or about Rs. 12 per month, being a clear return of Rs. 108 in the nine months. Hence there should be no hesitation in giving a good price for such a cow. If, on the other hand, Rs. 40 be given for a cow giving only 4 seers the money value of her produce does not average 8 annas a day which probably hardly covers her feed and keep, so that the profit is *nil* and the animal does not win back her price. Furthermore, if judiciously mated, the calf of the superior animal will be worth far more than that of the inferior cow. A cow well purchased is so much capital if properly managed, and a calf is an increase on that capital, and the cost of feed and keep should be more than balanced by the milk and ghee which she supplies.

If it is milk that is required, care should be taken in the selection of cows and only those of milking breeds should be purchased. A cow, may be a large, good looking, shapely animal yet may be practically worthless for the dairy. The best milking cows for Upper India are those of the Hissar, Hansi, and the Montgomery (Sahniwal) breeds. The former if fed properly generally do well in most parts of the United Provinces, although perhaps they will not give quite such a heavy yield as they do in their native climate. The Montgomery strain are smaller cows and very excellent milkers, although in some of the eastern tracts of the Province they are said to lose their milk-giving powers to some extent. The Kosi or Mewati strain which are usually bred in the tract of country known as Mewat are fair milkers but usually not so productive as the Hissar variety. Experiments have recently been carried out on some of the Government farms with a view of ascertaining if permanent improvement in the milk producing capacity of the Indian cow can be achieved by crossing with some of the noted British dairying breeds. Originally some prejudice existed in regard to this, as it was predicted that the progeny of such a cross having no inherited immunity would rapidly fall victims to the many animal epidemics in the country. Furthermore, it was stated that the bullocks would have little or no hump and for this reason would be useless

as working cattle. Thanks to the immunity conferred by protective inoculation the first objection has been found to be surmountable. With regard to the second, experience has shown that the necessity for the well developed hump has been greatly exaggerated and wherever Government military dairy farms are established, it is now no uncommon sight to see half- bred English cattle drawing immense load or carrying out other draught work ; nor does their working capacity appear to be in any way inferior to that of the pure country bullock. The Civil Veterinary Department has recently imported bulls of the celebrated Shorthorn and Ayrshire varieties. Many half-bred cows got by bulls of this breed have been known to give as much as 20 seers of milk daily. With regard to buffaloes the indigenous breed of these provinces are comparatively poor milkers. The breed known as Murrah which is found in the Rohtak District of the Punjab is perhaps the best for dairy purposes, and animals of this variety can usually be procured from the Jehazgarh and Amritsar fairs.

Intelligent selection and purchase, liberal feeding, careful management, attention to cleanliness, and hygiene as well as regular and systematic supervision are the factors which make for successful cow-keeping, and if greater attention and care were devoted to this industry in India it would have a far-reaching effect not only on the health but the wealth of the community.

RICE, AS PREPARED FOR FOOD IN BENGAL.

BY

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In those countries where it is only an article of import, rice denotes the husked and more or less polished grain of *Oryza sativa*. In the countries where this crop is grown, unhusked rice is so distinctive an article of commerce and domestic use that the English language has adopted for it the Malay word *padi* more usually written *paddy*, which corresponds to the Bengali word *dhan*. The large number of vernacular words each denoting paddy or rice in some particular condition or stage of preparation can, however, only be translated by the above simple names qualified by adjectives which readily escape the memory of an enquirer into the subject. Even when remembered they do not fully indicate the complex domestic or ceremonial usages associated with the vernacular words. It is thought that the publication of a brief account of these in permanent form may be of interest and of definite use as a first step towards a serious consideration of the varying dietetic values of rice used as a food-stuff in a major province of India. On this latter point, Hooper (*Agricultural Ledger*, 1908-09, Vol. V, p. 67) remarked that it appeared very desirable to undertake an investigation to ascertain something more than is at present known regarding the chemical composition of the various grains and supplied analysis of a given number of samples of rice. He also makes preliminary statements upon the nutritive value of these grains as they pass through different stages from paddy to more edible forms; upon

the losses due to polishing and cleaning, with reference to the work of the Louisiana Experimental Station 1904, and on the losses due to cooking. As an example of the last the following figures calculated to a water-free basis are instructive :—

	Rice (*Chal*)	Boiled rice (*Bhat*)	Loss
Albuminoids	7·9	7·2	0·7
Fat	0·3	0·1	0·2
Carbohydrates	90·7	83·5	7 2
Fibre	0·4	0·4	—
Ash	0·7	0·6	0·1
Total ...	100·0	91·8	8·2

Whilst most of the information about rice is of an historical or statistical character, a little of a domestic nature is available. In his Statistical Report of Bengal (1875, *et seq.*), a monumental work of 19 volumes, Sir W. W. Hunter records several hundred vernacular names for different kinds of paddy, then grown in the Province, whilst Sir Geo. Watt (*The Commercial Products of India*, p. 823) states that there are altogether about 20 botanical varieties of paddy, of which five are very distinct. The former writer (*loc. cit.*) has noted under each district a few preparations of rice, those for the Faridpur District (Vol. V, pp. 300-304), based on a report by Dr. B. N. Bose, the Civil Surgeon of the District, being the most detailed. An effort is now made to cover this ground more fully according to the following synopsis and to bring into prominence those points where it is thought that scientific enquiry may be most usefully directed.

Synopsis.

I. Khai. (paddy roasted, then husked mechanically.)

(1) *Murki* (sugared Khai).

Varieties .. (*i*) Gur Murki.

(*ii*) Sugar Murki.

(2) *Khai-chur* and *Moa.*

II. CHAL. (paddy husked in various ways.)

(1) *Alo-chal* (mechanically husked paddy-rice).

Preparations .. (*a*) Bhat.
(*b*) Payes.
(*c*) Polaw (pilaw).
(*d*) Sofeda.
(*e*) Ruti.
(*f*) Pithe.
(*g*) Saruchakli.
(*h*) Malpo.

(2) *Siddha-chal* (Paddy, steamed, dried and husked mechanically).

Preparations .. (*a*) Bhat.
(*b*) Panta.
(*c*) Monda.
(*d*) Khichuri.
(*e*) Bhuni Khichuri.
(*f*) Chal Bhaja.

(3) *Muri-chal* (Paddy, twice steamed and husked mechanically).

Varieties (*i*) *Alo-muri-chal.*

Preparations .. (*a*) Muri.
(*b*) Chal Bhaja

(*ii*) *Siddha-muri-chal.*

Preparations .. (*a*) Muri.
(*b*) Chal Bhaja.

III. CHINRE (paddy, macerated, slightly roasted and then compressed).

Preparations .. (*a*) Chinre Payes.
(*b*) Chinre Bhaja.

IV. Panchui, Handia, *etc.* (Rice saccharified and fermented by action of living organisms).

Varieties .. (*i*) Panchui.
(*ii*) Handia.
(*iii*) Kanji.

I. KHAI. LAI. PHARHI, LAWA DHAN (Sanskrit—*LAJA*).

Preparation. The paddy is roasted on sand (about 1 lb.) placed on the slightly concave floor of a *khola*, which is a conical earthen pot (about 12 inches high, 8 inches across the mouth and 12 to 18 inches across the base), from the side of which an entire strip has been carefully chipped away. This is heated on a wood or coal fire with a proper arrangement for regulation of heat to keep the temperature of the sand fairly constant. The heated sand is fairly constantly but gently stirred with a bundle of sticks or strips, newly cut from cocoanut leaves and used as a broom. When the sand reaches the proper temperature, which is tested by the immediate bursting of a small quantity of paddy thrown on it, about one or two ounces of paddy, previously slightly moistened with a little water or by exposure in the open air in the night for softening, are put on the hot sand and rapidly mixed with it. The paddy then bursts with leaps and sounds, as the starch swells into a spongy light mass. The starchy portion in this condition is called *khai*; the husks being either completely detached or remaining slightly adherent at their ends. The *khai* is mechanically separated from the sand and accumulated on the surface of it by a peculiar movement of the broom sticks and is then taken out from it. It requires a very skilful and well practised hand to take out the *khai* and husks from the bath, for one unskilled in the art will take out a considerable portion of the sand along with them or some of the husks and *khai* will be charred. In this way a large amount of paddy can be transformed into *khai* in a comparatively short time. For the preparation of good *khai*, rather big sized paddy is used, not less than a year old, otherwise all the paddy will not burst at the same time, or the resulting *khai* will be too small in size. *Kanakchur*, *Jhingeshal* and such other paddy are very commonly used for this purpose.

After the removal from the sand-bath or frying-pot the accumulated *khai* is rubbed on a piece of Hessian cloth, by which the adhering particles of sand become detached from it and collect by gravity on or below the cloth. The frier (*Bhajuni*) considers this sand a valuable article, as the older and more used the sand the better is the quality of the product. The next process is to sift the husks from the *khai* in a sieve of the following description. It is made of thin strips of bamboo woven at right angles to each other, leaving holes through which the husks only can pass. It is generally hemispherical in size ranging from 2 to 5 ft. in diameter. A sieve is half filled with crude *khai* and gently rubbed over with the palm of the hand in such a way as not to break the crisp *khai* and to leave a depth of about two inches of them between the palm and the sieve. The finished article thus obtained is stored in big dry earthen pots. The husks are used as fuel.

Properties and Uses. Khai is sometimes used as tiffin along with *murki, muri,* etc., but it is commonly prescribed as a main diet for sick persons, being regarded as a light and easily digestible substance. When fresh, it is chewed with pleasure, producing a faint cracking sound but if it absorbs moisture it becomes tenacious and then it is rather unpleasant to chew. *Lajapeah* (literally meaning a drink of *khai*) is a cold dilute aqueous extract of *khai* and is often prescribed as a light and easily digestible and stimulating liquid food, having an efficacy for stopping thirst and vomiting. *Lajabhakta* is prepared by mixing *khai* in hot water and is taken when cold. It is known as sweet, light, soothing, appetizing, tasteful, and soporific. When this preparation is filtered through fine cloth, the liquid portion called *Lajamonda* has essentially the same properties and is very frequently recommended by Kavirajes (Ayurvedic physicians) for children and old or delicate ladies.

Apart from the use of *khai* for edible purposes, it is almost indispensible in expressions of joy in connection with births, marriages, or the happy death of very old Hindus. The eighth day from the date of birth is celebrated by the free distribution of *khai* and other things to the children. In marriage it is used at different stages in different localities of the Province. If a man or woman

dies at a good old age leaving a long line of heirs, a mixture of *khai* and coins are thrown on the streets along which the dead body is carried. Such a mixture is also distributed during the *Sradha* ceremony (end of the mourning period).

(1) MURKI. (*i*) *Murki* (with *gur*).

Preparation. A certain quantity of *gur* is taken in an earthen or iron *kara* (a hemispherical pot) and dissolved in a minimum quantity of water. It is gently heated over an ordinary hearth and the mass is constantly but slowly stirred with a wooden ladle having a flat end called *taru*. In this way it is brought to such a consistency as to feel sticky between the fingers and draw into threads, when the pot is taken from the fire and placed on a straw ring on the floor in an inclined position. A small quantity of any form of crystalline dry sugar (generally powdered palm-sugar is used) is dusted on the edge of the surface of the *gur* towards the centre of the *kara* and briskly stirred with a small portion of the liquid and then gradually the whole of it is gently mixed with it. This process is called *bich-mara*. Then a requisite quantity of *khai* is added to it by instalments and thoroughly mixed with the prepared *gur*. Then the whole is massed together and kept in a cool place under the cover of a clean cloth. The object of the process of *bich-mara* is to introduce the nuclei of sugar crystals to the whole mass for hastening crystallization. While the crystallization is going on, the *khai* gets a thin layer of this *gur*, so the resulting product (*murki*) is coated with crystalline *gur*. This is a very ingenious and simple way of getting the *khai* coated with crystalline sugar. After a few hours the *murki* is taken out and transferred into a big dry earthen pot called *jala* and is then ready for use. In case the *murki* is not so dry as to be easily separable owing to bad manipulation or use of inferior quality of *gur*, some wheat flour is dusted over the product and it is then stirred and stored up. Sometimes flavouring substances such as powdered cardamom or cinnamon, camphor, etc., are added to impart their characteristic aroma and taste.

Properties and Uses. Good quality *murki* is a dry yellow, or amber coloured substance. Date molasses imparts to it a

somewhat redder tinge than cane molasses; and also it has a very characteristic pleasant aroma for which it is often preferred to the other. *Murki* is usually eaten with *khai* or *muri* rather than by itself but some children having too much liking for sweets take it without anything to moderate its sweetness.

(*ii*) *Sugar-Murki*. For the preparation of this article white crystalline cane sugar is used instead of *gur*, and if the sugar is not very pure, the solution is clarified with dilute milk. It is a perfectly white, dry, and attractive article of food, rather costly, and is ordinarily used as a diet by patients under Kaviraji treatment. Both varieties of *murki* are at times used in a mixture with parched peas and gram, such mixture being called *fut-karai-murki* (fut = fried, karai = peas, etc.).

(2) KHAI-CHUR AND MOA.

The methods of preparation of these two are essentially the same as that of *murki*; only a higher proportion of saccharine matter and spices are used, and the *bich-mara* process is done after the addition of *khai* to it so that a considerable amount of it becomes broken into pieces. When warm it is taken in handfuls and made up into small balls which on cooling become fairly hard. The *khai-chur* maker from time to time rubs his palms with a little ghee or dusts them with flour to avoid stickiness. *Khai-chur* is generally made with sugar and *moa* with *gur*, but essentially there is no difference. These are used as sweetmeats.

II. CHAL. CHAUL (Sanskrit—*TANDUL*) English—*RICE*.

(1) ALO-CHAL (Sanskrit—*Atop tandul*).

Fresh or old paddy is freed from defective grains by uniformly spreading about five seers of it on dry clean ground about two feet in diameter and then blowing air on it with a *kula* (an instrument made of thin strips of bamboo used chiefly for winnowing). The defective paddy will separate off at a distance leaving the good grain. The process is repeated till several maunds of paddy are freed from dust and defective corn. Rice is prepared from this paddy when thoroughly sun-dried. The method of husking is almost the same as has been described by Sir G. Watt (*loc. cit.*), only it may be

mentioned here that two men are not indispensable for this purpose; some clever workers can do it alone. In several places rice-mills are established where this work is done with much facility. From this rice, *khud*, *tunsh*, and *kura* are obtained. This rice is called *Alo-chal.*

Properties and Uses. *Alo-chal* is not eaten without some process of softening but may be offered in dry condition to Hindu gods and goddesses. For the latter purpose it is more frequently carefully washed with the holy water of the river Ganges and kept in the shape of a solid cone on a disc of wood, brass, copper, or silver. On the top of this cone there are often placed some sweetmeats called *naibedyas* which after the *puja* are distributed among the priests, together with the rice which is then transformed into *bhat* and eaten. The Hindus celebrate the new paddy of the year on a Thursday of the month of Agrahyan (from middle of November to that of December) which is called *nabanna* (means new-rice). *Alo-chal* prepared from very good quality of new paddy is mixed with various kinds of edible roots and fruits, milk, *gur*, and other sweets, and offered to gods and goddesses, after which it is eaten by all the members of the family; but until this ceremony is finished, orthodox Hindus will not eat the new rice in any form. Cold aqueous extract of this rice called *tandul-odok* (rice-water) is prepared by mixing rice or its powder with about four times its own weight of water and then filtering it, which is prescribed as a diet only to certain patients by Kavirajes.

Khud is the broken rice and regarded as a waste product. It is either given away as alms or utilized as a food for milch cows after softening it in water. It has a very nutritious effect on cows as they apparently give more milk when fed with this.

Tunsh is the husk of larger size; it contains rice oil (*Cf. Jour. Chem. Soc. Indi.*, 1893, 848). It is chiefly used as fuel, but it is also mixed with clay along with a little cow-dung for plastering purposes. *Tunsh* and clay plaster is very tenacious and does not crack on drying.

Kura or Gunra. This is a mixture of powdered husk and parts of rice. It is chiefly used as a cattle food and is specially liked by

milch cows. If thrown into a pond in either the raw state or parched it acts as a most effective grain bait for fishing.

(a) *Bhat.*

Alo-chal is boiled for 20 to 30 minutes with about 4 to 5 times its weight of water. When sufficiently softened it is taken from the fire and the excess of water, which has become thick with some broken or loose particles of burst starch, is decanted off. This softened rice is *bhat.* It is taken out from the boiling-pot and spread on a plantain leaf, cotton cloth or metallic or stone plates for cooling if necessary, when it becomes ready for use. New rice has a tendency to soften too much; however carefully it is cooked or the temperature and time regulated, its gelatinizing property causes it to form lumps when cooled. The strained liquid is called *fan* and so is generally used as a drink for cattle.

Properties and Uses. Unless the *chal* itself is coloured, the *bhat* of *alo-chal* is as a rule white and very nice to look at. This *bhat* is regarded as more nutritious but less digestible than that from *siddha-chal.* It is generally eaten among orthodox Hindus who want to keep a closer touch with religion and want to live a pious life, by priests, old Brahmins, old widows, mendicants, and mourners. The reason for considering it as a suitable food for the pious is that it is practically a natural product, since as *chal* it has not undergone any process of cooking or steaming but is husked by means of mechanical treatment. The tendency of the Europeans to use this rice preferentially originates from the fact that its *bhat* is whiter than any other. The Indians believe it to be an approved an-aphrodisiac article of food. The only reason why this is not used as a staple food in preference to *siddha-chal* is that it is more costly than the other owing to the large amount of rice lost during the process of husking. *Fan,* under the name of *monda,* is prescribed as a diet for certain patients by Kavirajes when prepared with special care suggested by them. They regard it as an essence of *bhat* mixed with a little soluble starchy matter. Ordinary men find it difficult to digest and it is also supposed to contain more

nutritious matter than *bhat*. Putrefied *fan* is sometimes used as a manure for certain creepers producing edible fruits. According to Chakra and Bhabprakash, when *bhat* is washed with water it becomes more digestible and it is a common practice among the Bengalis, when a man is suddenly attacked with diarrhœa or indigestion, to take *bhat* that has been previously steeped for some time and washed in cold water, because it is considered to become easily digestible by these processes.

(b) *Payes or Paramanna.*

There are about forty different recipes for the preparation of *Paramanna* (Param = good, high ; *anna* = rice). Generally very good quality *alo-chal* is selected for this purpose, *i.e.*, which has fine and clean grains and much aromatic oil in it. Generally the varieties known as *Banktulsi, Dadkhani, Kamini, Banshmati, Gopalbhog*, etc., are chosen. The rice is thoroughly washed and transferred into a pot and sufficient water added to cover the rice to the depth of an inch ; then it is very gently heated, no time should it be boiled briskly. When the rice is about half-softened so that the outer half of the rice is soft but the inner part remains as stiff as before, hot and half concentrated milk is added to it and gently stirred to mix it thoroughly. The quantity of the milk to be used varies considerably, depending on the quality of the produce wanted. Then a sufficient quantity of a sweetening agent, such as pure cane-sugar or cane or date-molasses is added. After gently boiling for a few minutes some flavouring substances such as cardamom, powdered cinnamon, camphor and some fruits like raisin, pistachio, almond, etc., are added.

Properties and Uses. *Payes* prepared with sugar is white but that with molasses is of pale brown colour. It is a mixture of thick syrupy liquid with *bhat*, emits either the natural odour of the rice or that of the spice added to it, and is a rich, delicious and tasteful article of food. As a rule it is not used daily by any class of people but it is almost indispensable on all festive occasions except those where preparations of rice are unallowable.

(c) *Polanna or Polaw.*

Polanna is a Sanskrit word and its method of preparation can be found in several old Sanskrit books. The other word *polaw* has probably been introduced by Mahomedans during their rule in India. It was a well-known favourite food of most of the Mahomedan kings and emperors. For this purpose good rice such as *Kamini*, *Banktulsi*, *Banshmati* and *Dadkhani* is chosen. *Alo-chal* is generally used but it can also be prepared with *siddha-chal.* The rice should be free from broken grains and should be at least two years old. There are more than 100 different preparations which may be classed under this heading, combinations in various quantities of various choice articles of food. The following description will only afford an idea of the general principle of its preparation. Good clean *chal* is gently rubbed with cow's ghee and saffron, and placed in the sunlight. As soon as the ghee soaks into the rice another coating of it is given. This is repeated till the process of soaking is complete. It requires a few hours preparation in sunlight. If prepared without colouring matter, the finished article will be called *ghee-bhat* and not *polaw.* A decoction, called *aknir jal*, of several spices such as cardamom, cinnamon, cloves, coriander, etc., is now prepared whilst the rice is mixed with raisins, pistachio, etc. In a *dekchie* a layer of *tejpata* (cinnamon leaves) is spread with some ghee, then some pieces of fried fish, meat, or lumps of congealed milk with some of the rice are put on it. This is covered with another layer of *tejpata* and ghee, and similarly another of rice and *tejpata* is arranged on it. Next, the above prepared decoction is added till its surface rises about 2½ inches above that of the rice. To impart flavour, sugar, curd, salt, etc., are added in various proportions. The *dekchie* is now covered with a lid and gently heated over a bright fire. After about 20 minutes when the rice is not yet completely softened, it is removed and kept on a smouldering hearth, with some lumps of glowing charcoal on the lid, so as to keep the temperature of the *polaw* high for a considerable time to soften the rice completely, a process which is called *dom.* Sometimes delicate perfumes are added at the end, musk being formerly much used for the purpose.

Properties and Uses. *Polaws* are very delicious, fragrant articles of food. These are very nutritious and rather difficult of digestion, being commonly used among the rich classes, but only cooked by others on festivals.

(d) *Sofeda and Pituli.*

Good *alo-chal* is macerated with water for about twelve hours or more, then the whole is put on a new cotton cloth through which much of the water percolates out; it is then put on a piece of dry cloth which soaks up all adhering water. This rice is crumbled and the coarse powder is passed over a sieve of coarse cloth. The residue is again crumbled and sieved and finally a small part is neglected to be used as a cattle-food. The *sofeda* thus obtained cannot keep long unless perfectly sun-dried and stored in a dry pot. This is simply *alo-chal* powdered by a heavy grinding stone. Some people call it *chal-ata* (rice flour).

Pituli is a pasty mass of powdered *alo-chal* generally prepared only in small quantities by rubbing moist *alo-chal* with a little water on a rough stone surface with a similar stone roller.

Properties and Uses. It forms a white powder very much resembling flour. It is not directly used but it is the main ingredient in the preparations of *pithes*, *saruchakli*, *malpo*, etc. Now-a-days it is used as a fraudulent substitute for wheat flour in preparations of several good sweetmeats such as—*pantua*, *rasagolla*, etc.

(e) *Ruti.*

Sofeda is treated with boiling water in the same manner as in the preparation of *puli* (see later). The whole stuff is made into a solid ball by thorough rubbing and pressing. It is then divided into small balls of about $\frac{3}{4}$ inch diameter. These are next flattened into thin circular discs, and are subsequently roasted on a hot iron plate and these are known as *ruti*. Sometimes salt, sugar, etc., are mixed with it as fancy requires.

Properties and Uses. *Ruti* is a soft white substance and is not so attractive as several other preparations unless it is suitably flavoured; it is difficult of digestion and only occasionally used by Mahomedans and some up-country people.

(f) *Pithe or Pistaka.*

By *pithe* several preparations of powdered rice are meant, particularly (1) *aske* and *puli* or *siddha-pithe* or *chaka*, and (2) *puli*, *siddha-puli* or *chaka*.

(1) *Aske*. *Sofeda* is mixed with water to form a thin paste. About a fluid ounce of it is poured on a hot pan smeared thinly with a little mustard oil ; then it is covered with an earthen cup. After some time the cup is removed, when the cake is taken off with a ladle. This is *aske*. The object of covering is noteworthy. It retains practically all the water vapour by reverberatory process, and causes softening of the starch by continual steaming. If it were not covered the stuff would have dried before the softening of the starch grains. *Aske* is a white double convex cake having a taste like *bhat*. It is usually taken with *gur* or its syrup but may also be taken with curry.

(2) *Puli*, *siddha-puli or chaka*. *Sofeda* is gradually poured into boiling water stirring vigorously all the while till a thick paste is formed. When cooled it thickens and if it is not thick enough it may be made so with a fresh quantity of the powder. About half an ounce of this substance is taken and shaped like a cigar with a little dried milk in a solid state or some sugar preparation inside it. Several of these are put in a pot containing boiling water and very gently boiled for about half an hour, when they become ready for use. At some other places, however, they are steamed on a cloth tied on the mouth of a pot where some water is boiling. In this way the material is softened by steam under a cover of a lid above and direct saturated vapour below, for about an hour. The products obtainable by the two processes are practically the same. They are eaten on similar occasions as the *aske*, that is in the end of the Bengali month Poush, middle of December. The properties of *pithes* are similar to those of simple *bhat*.

(g) *Saruchakli.*

A thin syrupy paste is made of *sofeda* and water which is called *gola*. Sometimes salt, *gur*, paste of *dal* and wheat flour are added according to the taste required. The consistency at this

stage has a very important effect on the finished product. About a fluid ounce of *gola* is taken in a small cup or spoon and poured evenly upon a flat frying pan previously rubbed with a little mustard oil or ghee on a slice of brinjal or potato. Then it is immediately spread to a uniform thin circular disc with a simple spatula of palm leaf cut like a knife-blade. After a short time when the lower portion of the disc, called *saruchakli*, is somewhat baked, it is lifted with a thin ladle, care being taken not to break any portion and then turned over for baking the other side. The ladle is then pressed on some parts of it so that the baking may be uniform, and when finished the disc is taken out and folded into a quadrant. This is one of the delicate preparations requiring considerable skill and practice.

Properties and Uses. *Saruchaklis* are sometimes as thin as paper but commonly they are made as thick as $\frac{1}{4}$ to $\frac{1}{8}$ inch. These are soft and are not generally eaten alone but with treacle or curry. Though not a delicious food yet it is taken as an alternative.

(h) *Malpo.*

Gola is prepared in the same way as above with additions of sugar, dried milk solids, spices, etc. About an ounce is poured on a hot bath of ghee and fried carefully. This is *malpo*, it is also prepared with curdled milk and other ingredients.

Properties and Uses. These plano-convex discs of about 2 inches diameter are a brown to yellow colour, of delicious flavour and commonly used as a sweetmeat.

(2) Siddha-chal, Bhater-chal or Boiled Rice.

Paddy is cleaned as described under *khai* and macerated with an excess of water in large vats for about three or four days, then taken out and placed in an earthen pot or a tinned iron can, containing a small quantity of water which is heated till steam is seen to penetrate all the paddy. This process of steaming causes the husks to burst. The steamed paddy is then dried in the sun to a definite degree which is determined by pressing it between teeth. It is husked by the usual process. The products are *siddha-chal*, *khud*,

kura and *tunsh.* The latter three by-products are used like those from *alo-chal* (q.v.). The finished article is then stored in gunny bags and is ready for market.

Properties and Uses. Siddha-chal has a characteristic transparent greyish white appearance in contra-distinction with *alo-chal.* It is less brittle than the latter. During the process of steaming before husking nearly all the grain is swollen and resembles *bhat* but it again contracts when dried. This is the cheap variety forming the staple food, *bhat,* of most Bengalees. Its *bhat* is believed to be more easily digested than that of *alo-chal.* It is more easily husked than the other and also with much less loss. This largely explains the preference shown for *siddha-chal,* but the rice produced is greyer than *alo-chal.* Probably this accounts for its being not used as a table-rice by Europeans. Its *bhat* can be softened to a considerable extent without that stickiness and gelatinization found in *alo-chal.* It is generally regarded as less nutritious than the other, but this is not completely corroborated by scientific experiments. There may be some truth in it because some of the nitrogenous matter may have been extracted and lost during the process of steaming.

(a) *Bhat.*

The *bhat* is prepared in the same way as that from *alo-chal,* only it takes a little more time to soften; the older the rice the more is the time required for softening. The *fan* is also produced as before.

Porer bhat. This is prepared from old small grain rice by heating over a dim and slow heat produced by a heap of burning cow-dung cakes. In an earthen pot the rice with four times its own weight of water is taken and covered with an earthen lid and placed on the fire. It very slowly but steadily boils for not less than an hour, after which the pot is taken out. Generally the whole of the water added disappears by soaking and evaporation, consequently very little is left as *fan.* This food is regarded as nutritious, easily digestible and tasteful. and is chiefly used for children and invalids. These special properties it acquires by the slow and lengthy process of cooking so that all the particles of starch are completely softened.

(b) *Panta : Panta Bhat : Pakal Bhat.*

Bhat is prepared in the usual way, the *fan* being strained off. When it is perfectly cooled to the air temperature after three or four hours sufficient cold water is poured on it so as to cover about ½ inch deep. On keeping it covered for at least 24 hours it becomes ready for use. It retains its taste for two or three days. The fluid portion is called *amani* or *torani*, and the [illegible] is called *panta, panta bhat* or *pakal bhat. Amani* may also be specially prepared in the following manner:—In a new earthen pot about half a seer of softened rice is taken and filled with pure water and after covering with a piece of cloth it is kept under the direct heat of the sun. Next day another instalment of fresh *bhat* is added and similarly left under the sun and so on up to three or four days. Then the clear transparent upper liquid called *amani* is decanted out and drunk.

Properties and Uses. Panta has an acid taste only, otherwise it is similar to fresh *bhat.* It is generally used by labouring classes who prefer it as cooling and refreshing. When eaten it is very often mixed with lime or lemon juice or with preparations of some acid-containing fruits and a little salt. The fluid portion, the *amani* or *torani* is used as a cooling drink and also sometimes prescribed as a diet by Kavirajes.

(c) *Monda, Fan, Mar.*

Monda is another name of *fan* as stated already. But the *fan* obtained as a by-product from the preparation of *bhat* is not quite similar to that described below. In a new earthen pot one part of washed, good, old rice is taken with 14 parts of water and boiled till completely softened. Then after straining out the *fan* it is mixed with one part of warm water and thoroughly ground in a mortar by a pestle. When it forms a pasty mass it is mixed with a fresh quantity of water and filtered through a piece of fine cotton cloth. The filtrate is the true *monda* to be used with a little salt, powdered ginger, and lemon juice. It is a very easily digestible, light and tasteful article of diet. Commonly, however, *fan, monda* and *mar* imply the same thing; the above

is a special preparation used as a diet only by some classes of patients.

(d) *Khichuri*, *Kicharanna*.

There are no less than 30 different preparations of *khichuri*. These can be prepared either from *alo-chal* or *siddha-chal*; those with the former are not necessarily finer than with the latter. Commonly *siddha-chal* is used for this purpose, hence it is described here. The essential constituents in this preparation are *chal* and *dal* (pulse); they are mixed at different stages in various proportions. There are several preparations with fish and meat, but as a rule good *chal* and *dal* are used in its preparation. When rice is half softened by boiling, a quantity of *dal* which varies from one to four times that of the rice, is added. Next turmeric, raisin, pistachio, almond, sugar, ghee, salt, etc., are added. Sometimes fried fish, egg, meat, dried milk solid, etc., are added. When both the *dal* and rice are softened, the mixture is withdrawn from the fire immediately after addition of powdered spices. It requires much skill and care to cook it as here no *fan* is eliminated. There is a great chance of the mass charring and sticking at the bottom of the pot. In case there be any excess of water, the pot with the substance is placed over a smouldering fire.

(e) *Bhuni khichuri*.

There is another class of *khichuri* called *bhuni khichuri* (Bhuni = fried) prepared with *chal* and *dal* that have been fried after smearing with ghee; otherwise it is same as ordinary *khichuri*.

Properties and Uses. It has a pleasant appetizing odour, a yellow to brown colour, and a delicious taste. It is a rich food, difficult of digestion, commonly used as an article of luxury taken on some special occasions, *e.g.*, picnics, rainy days, etc. It is known to have a very heat-producing effect on the human system, so it is more frequently used in winter. Travellers often prefer it to simplify cooking. It is generally eaten while hot or warm, as the cold stuff is less tasteful.

(f) *Chalbhaja.*

Ordinary *siddha-chal* is moistened with a little water and salt and rubbed gently but thoroughly to give it uniform coating of salt, and then roasted on a sand-bath as in the preparation of *khai;* the product is called *chalbhaja.* This is also sometimes roasted in a hot iron kettle when the product is called *chalbhaja* of *kat-khola.* The preparation is hard and requires much chewing, is not very palatable, and also digested with difficulty. But when mixed with mustard oil, red pepper and a little salt it is relished by the labouring classes as also by healthy young people.

(3) Muri-chal.

There are two varieties of *Muri-chal :—*

(i) Alo-muri-chal ; (ii) Siddha-muri-chal.

(i) *Alo-muri-chal.* Paddy is taken in a basket and placed over a new unused pot containing some water boiling in it. Then the paddy is covered with a clean cloth; all the steam that comes out must pass through all the paddy. This process of steaming is continued for half to one hour. The grain is taken out and put into a large vat of water and allowed to macerate for three or four days. By instalments a large quantity of paddy is steamed. After maceration it is taken out from the water and steamed again as before, then dried and husked in the manner already described. The by-products, namely, *khud, kura* and *tunsh* are also similarly used as before.

Properties and Uses. This rice resembles *siddha-chal* in appearance. It is only used after its conversion into *muri* or *chalbhaja.* Its method of preparation is more costly than that of ordinary *muri-chal* and the products obtained from this rice are inferior to those from the other. The *muri* and *chalbhaja* from this rice are exclusively used by old Hindu widows who live on *alo-chal* only.

(a) *Alo-muri.*

Alo-muri-chal is washed with water and rubbed with a small quantity of salt, then transferred into a large shallow earthen kettle or *khola* and placed on a hearth. It is very gently

heated, being constantly stirred with a wooden ladle. This process is called *onja.* At first the adhering water evaporates, then the temperature slowly rises and gradually all the rice becomes brown amber coloured. At this stage it is removed from the fire. In this process a considerable portion of the starch is probably dextrinized. Then it is usually parched on the sand-bath as described under *khai.*

(b) *Alo-chalbhaja.*

Chalbhaja from this *chal* can be prepared by dry heat, either with or without sand, and its properties are almost the same as those of *siddha-chalbhaja.*

(ii) *Siddha-muri-chal, muri-chal.* Clean paddy is taken in a fairly large sized earthen pot with about one seer of water and very gently heated till steam is seen to escape. At this stage the heat is carefully regulated so that steam only just escapes. It is kept in this condition for about quarter of an hour and then poured into a big earthen or wooden vat. When sufficient has accumulated it is covered with water to a depth of three inches. It is left in this condition for three or more days when it is taken out and steamed again, dried and husked in the usual manner. The rice obtained is called *muri-chal.* The by-products are also similarly used as stated before.

Properties and Uses. Muri-chal looks slightly darker than *siddha-chal.* It is solely used for the preparation of (a) *muri* and (b) *chalbhaja.* Of course it is not impossible to prepare *bhat* from this rice but its taste would be quite different from ordinary rice. Its *bhat* does not taste sweet as that from other rices. It is due to this special process of preparation in which the starch is so changed that its taste is quite different.

(a) *Muri.* For its conversion into *muri* this rice is treated in exactly the same way as *alo-muri-chal.* Bulk for bulk it swells more than the other. It is a greyish white, brittle and dry substance, and is an easily digestible, light food. In villages it is prepared by each family for its own consumption and is also prepared in quantities by sweetmeat makers and vendors. It is used as a cheap and easily procurable article of tiffin. Almost all healthy

village people, young or old, rich or poor, use it for this purpose. It may be taken as it is or smeared with a little mustard oil, red pepper and salt, followed sometimes by *gur* or sweetmeats.

Muri is appreciably hygroscopic; when exposed to damp air it rapidly absorbs moisture and loses its brittleness and then it is not readily chewed and is rather unpleasant. In this condition it does not crackle in the mouth and is called *miono-muri*, 'miono' meaning soundless.

Muri is sometimes mixed with milk, curdled milk, plantain, mango pulp, etc., before eating. Such mixtures are called *falhar*. *Falhar*, however, can also be prepared from *khai* or *chinre*.

Muri-chak and *muri-moa* are prepared just in the same way as *khai-moa*. The *muri-chak* is shaped into thick circular discs and the *khai-moa* into balls.

(b) *Chalbhaja*. *Chalbhaja* from this rice can be prepared by the same method as *chalbhaja* from other rices, but this variety is more tasteful and easily digested. This stuff is used like *muri* but less frequently. It is very seldom taken alone, being always mixed with parched grams, peas, etc., and smeared with mustard oil, pepper and salt. In Calcutta there is a common and well-known preparation of *chalbhaja*, called *abak jalpan* (*abak* = dumfoundered; *jalpan* = tiffin, *i.e.*, a food so good that one is dumfoundered). This is chiefly a mixture of good *chalbhaja* with parched peas, grams, etc., flavoured with mustard oil, red and black pepper powder and several other spices. It is sold as one-pice paper packets folded to form a solid cone. It is a tempting substance specially to children who take it in the afternoon.

Gunda literally means powder; but powders of *muri* or *chalbhaja* are called by this name. It is generally eaten with molasses or treacle, and is also sometimes prepared from fried *khud* for economy. It is not ordinarily sold in the market but prepared for family use.

III. CHINRE, CHIRA, CHURA (Sanskrit—*CHIPITAK*).

Any paddy is taken and steamed in an earthen pot as previously described, and then macerated in a vat of water for two or three days. Then it is taken out from the water and kept in a basket so that the

adhering water drains away. When drained, it is transferred to the *dhenki-sal* or husking-machine adjacent to which a hearth is ready with a sand-bath on it. It is heated in the sand-bath until there is evidence of parching, *i.e.*, a little *khai* is formed. Then it is immediately taken out on a *kula* and freed from sand by winnowing and at once subjected to the working of the *dhenki*, while still very hot. The *chinre* is purified from the *tunsh*, etc., which are eliminated by the usual process. The preparation of *chinre* requires the utmost skill so much so that it is still restricted to a particular class of people called *chutar*. This work is generally performed by women; all the operations are finished while the *chinre* still remains sensibly hot, it is then air-dried or sun-dried if necessary and stored up in gunny bags, or big earthen or wooden jars.

Arwah chura or *arwah*. In certain places paddy is allowed to soak completely in water (for three or more days) then partially dried in the sun, heated and crushed by the *dhenki* or by some similar means and cleaned. The *chinre* thus obtained is called by the above names. This can also be made with half ripe paddy.

Usna chura or *joshanda* is prepared by steaming or boiling paddy with water and partially drying under the sun; it is then usually bruised in the *dhenki* and cleaned.

Properties and Uses. Chinre is a fern-like flat greyish white substance corresponding in colour to the rice used. When steeped in water it considerably swells up and becomes as soft as *bhat* or sometimes softer. It may be then eaten with *gur* or some such sweetmeats, but it is most pleasantly eaten after mixing with the various tasteful substances noted already under *falhar*. It is a valuable article to travellers and orthodox Hindu tourists or pilgrims, as it can be readily prepared for food without cooking; besides it has a special advantage that it is not more costly than *bhat*.

Water of chinre is a cold aqueous extract of *chinre* prepared by simply steeping it in water for a certain length of time. The clear water is decanted off with the greater part of the soluble matters (sugars, soluble starch, etc.) in solution. This is regarded as a valuable diet for patients suffering from some stomach diseases.

(a) *Chinre Payes.*

One part of sugar or *gur* and about 8 parts of milk are boiled for about 20-30 minutes for concentration, then a very good quality of *chinre* is washed and put into it. When this just commences to boil, it is taken from the fire and kept in a warm place. This is used on the same occasions as *payes* made from *alo-chal* and is equally delicious. To it also raisins, pistachio, sweet almond kernel, and spices are added.

(b) *Chinre bhaja.*

It is prepared in the same way as *muri* by parching *chinre* on a sand-bath. It is used instead of *muri* but less frequently than the latter. It is also often used in a mixture with several other fried substances.

Chinre chak is a preparation corresponding to *muri chak* prepared, sold and used side by side with it. It is a good substance to be taken at the tiffin time if prepared with proper care.

IV. PANCHUI, HANDIA, AND KANJI.

Preparations of alcoholic drinks from rice starch appear to be of relatively modern origin. In early days they were chiefly obtained from saccharine juices of fruits and trees and from *gur*. Among rice preparations containing spirit (i) *panchui*, (ii) *handia* are very well-known. For their preparation rice and *bakhar* or *ranu* only are necessary. Any kind of rice is used, the *bakhar* is purchased as greyish cubes, balls or simply lumps. This first converts the starch into sugar and then to alcohol. The English synonym for *bakhar* is generally accepted as yeast which is scientifically unsatisfactory as yeasts are those which convert invert sugar into alcohol but *bakhar* is also a saccharifying agent.

(a) *Panchui.*

Bhat is prepared in such a way that the grains do not gelatinize or stick together. The *fan* is strained out if necessary and the *bhat* is spread on a piece of cloth or on plantain leaves for cooling. While it is still warm, *i.e.*, slightly higher than blood heat, the *bakhar* is spread over it and roughly mixed together and

stored in a pot. It is then kept covered in a warm place for 24 hours. During this time a considerable part, if not all, of the starch is transformed into sugar. In certain places it is diluted at this stage while in others it is kept as it is and diluted after five or six days. After the fermentation is complete it is sometimes further diluted; then by filtration or by decantation clear liquid is obtained for drinking purposes. The undiluted substance is called *panchui* and the diluted one is called *rashi* but this nomenclature is not general.

Properties and Uses. Panchui is in fact a rice beer from which pure spirit can also be obtained. It has a pale yellow to brown colour and a very characteristic acid odour. Its alcoholic strength varies from any low figure to as high as 39 per cent. proof spirit, whereas in ordinary fermented liquors it scarcely rises above 23 per cent. proof spirit. This is mainly used by lower classes of people who cannot afford to purchase costly liquor.

(*b*) *Handia.*

This preparation is made and taken by the comparatively poorer classes of *dhangars* (sweepers), etc. This is very similar to *panchui* and the mode of preparation is also the same as that of the latter, excepting that instead of freshly boiled rice, refuse boiled rice (sometimes even partly decomposed) is somewhat dried in the sun and the *bakhar* subsequently added.

Although the finished product is relished by its users, yet it has much more of the putrid smell than ordinary *panchui*, as in the former there is a lot of decomposed food matter besides the rice.

(*c*) *Kanji.*

(Sanskrit—*Kanjik*).

This is prepared by steeping 2 seers of powdered *aus* paddy (an early growing variety) in 8 seers of water in a pot which is kept covered and buried under earth. It is kept in this condition for at least 15 days and the clear liquid decanted out. It has an acid taste and odour like acetic acid. Dr. U. C. Dutt in his *Materia Medica of the Hindus*, page 12, while describing *kanji* has not dealt with the chemical processes of the fermentation of acetic acid, but

only stated that sour liquid is produced by the acetous fermentation without any mention as to whether any alcoholic fermentation takes place at an intermediate stage.

Probably its composition is similar to malt vinegar. It is directed to be used as a cooling and refrigerent drink in fever. It has a soothing effect on burning skin. It is generally used by Kavirajes as a vehicle for medicines.

V. Conclusion.

The proper conclusion of such a paper would have been remarks about the comparative merits of the different preparations, but unfortunately no scientific data are available for that. In many instances the properties of preparations have been taken from authors of Kaviraji Shastras such as Chakra and Bhabprakash. There is a correct notion that the digestive properties of different rices are different, and that an old rice is more easily digested than a new one of the same variety. The starch is considerably swelled up in *khai*, its exact nature is not known. It is highly needful to settle the real merit of such preparation as food. Regarding the varieties of rice—*alo-chal*, *siddha-chal*, *muri-chal* and *chinre*, chemical examination could really ascertain how far they are different.

The need for slow heat in cooking has been realized in the preparation of *porer bhat*, and in producing *dom* of *polaw*, etc. For these purposes steam-bath could be recommended for convenience and perfection. Cooking by steam-bath has already been introduced by Dr. I. M. Mallik whose patent apparatus is called the "Ic-mic cooker"; to popularize this Dr. C. L. Bose in his book "Khadya" (food-stuff) has amply described its use. By the adoption of such a method improved results are expected in cooking *bhat* for infants and invalids and in preparing rich, delicate and fanciful preparations like *khichuri*, *polaw*, etc.

Among the liquid preparations from rice nothing is known about the chemical constituents of *amani* and *kanji*. The *panchui* and *handia* are used as spirituous preparations but they contain extractives, etc., other than alcohol. At present the spirit obtained from rice starch is called *dheno-mad* (dheno = from paddy;

mad = intoxicant or intoxicating liquid). If the rice spirit has all along been prepared from rice and not from direct paddy then its name more probably would have been *chalo-mad* instead of *dheno-mad.* This naturally suggests that preparations of spirituous liquids could be directly started from paddy, either by powdering or by macerating and steaming without passing through the intermediate process of husking. In that case spirit could be obtained at a much cheaper rate. It is not known whether any attempt has been made to prepare spirit from *khai, muri,* and *chinre.* The first two are expected to imitate malted beers. The facts in favour of the last are that it is of about the same price as its equivalent rice and it does not require boiling for softening, simple steeping being sufficient.

Fig. 1. Harrow at work.

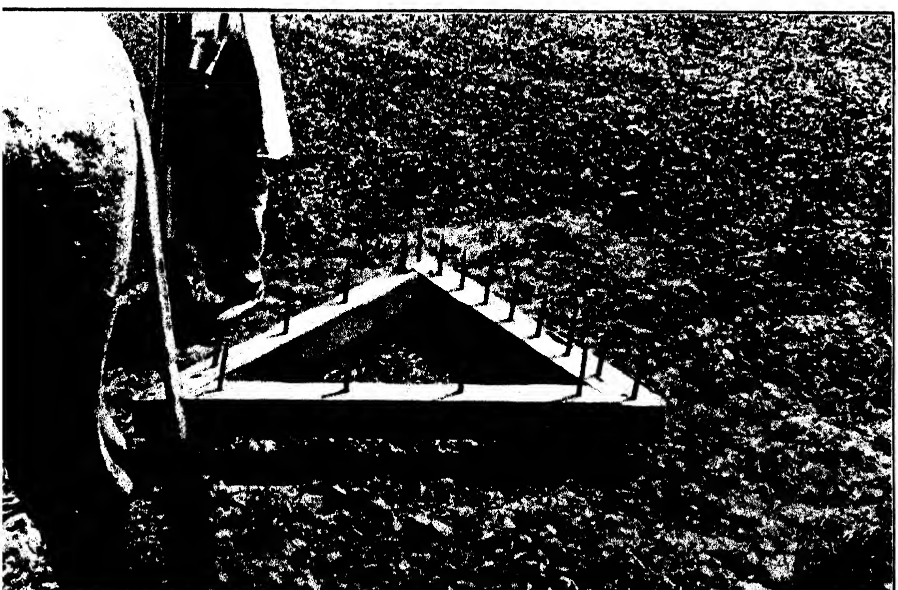

Fig. 2. Harrow reversed for taking off the field.

NOTES.

A Triangular Harrow for Wheat. The harrowing of young wheat has engaged attention at Lyallpur since 1910 when Milligan tried the Parmiter Chain Harrows here. Some benefit was immediately observable in that the wheat tillered better and became more robust after harrowing. Less danger of white ants attacking the crop was also observable as the latter do not relish vigorous growing plants. Later in 1911 and 1912 some Chain Harrows were tried by zemindars here and also in Gurdaspur. While admittedly some benefit was obtained the price of the Harrow, *viz.*, Rs. 65 at Lyallpur was a great deterrent to its extended use. It was found also that though good results were obtained on light land and on all land before the first irrigation or "kor," the Chain Harrow was not sufficiently strong to break the crust after irrigation. In the last two years we have used the Lever Harrow here, this having given good results with Howard in Bihar. This harrow did better work than the Chain Harrow, and owing to the possibility of adjusting the tines to slope slightly backwards or forwards was better able to tackle wheat during "kor" (*i.e.*, before the first watering) than the Chain Harrow. It was found, however, that even with two harrowings very little effect was obtained generally on irrigated wheat. Besides, the price which in Lyallpur was Rs. 37 was somewhat heavy, especially as these harrows are of special use only for this one operation. Four acres a day can be harrowed once with the Lever Harrow as compared to seven or eight with the Chain Harrow. It was felt therefore, that the problem, being an economic one, a cheaper harrow

had to be evolved. The best design for this purpose proved to be an adaptation of the Triangular Harrow first seen by the writer at Coimbatore in 1913. Some of its advantages are described by Sampson in the *Agricultural Journal of India,* Vol. III, Part I, January 1908.

The type finally adopted here this last autumn and which has done excellent work is shown in Plate IV.

The following points about it may be noted :—

(1) It can be made by local carpenters in the villages. The cost is Rs. 6 at Lyallpur.

(2) The tines slope slightly backwards ; about 12° is ample.

(3) The weight for young wheat should not be more than 30 seers.

(4) After first irrigation the harrowing is more severe and extra weight should be added. Twenty seers is generally added here.

(5) The tines are specially hardened by the native process known as "Pan."

(6) The tines should be pointed and should be tapering in the part passing through the wooden frame. If this is not done, the pegs are apt to get loose in the wood (*see* Diagram).

They are secured from falling out by a pin at A.

(7) The harrow has only 17 tines as compared to 30 in the Lever Harrow and thus deeper harrowing is possible and very often one harrowing suffices in place of two with the Lever Harrow.

(8) Four acres a day can be harrowed once with it.

(9) For taking the harrow off the field, it is only necessary to reverse it when it travels on the rests at the three corners.

It was found that wheat could be harrowed at any stage up to 8″ high with these harrows without doing appreciable damage and

with very good effect on the general health of the crop. This harrow can also be used for gram with beneficial results.

[W. Roberts.]

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Teff Grass.—In the Cawnpore Farm Reports for 1914 and 1915 figures are given for the yields obtained with Teff grass (*Eragrostis abyssinica*) when grown as a cold weather irrigated fodder crop. It is shown that in favourable circumstances a yield of approximately $1\frac{1}{2}$ tons of hay of good quality, or 5—6 tons green fodder can be obtained between December and May at a time when green fodders are frequently scarce. Teff grass is a quick growing crop and is, therefore, of great use in irrigated tracts, when there is any shortage of fodder. Sown at the beginning of December, it yields its first (and heaviest) cutting about the middle of March and a subsequent cutting at the beginning of the hot weather. Experimental work with this crop is still going on, but it has been found desirable to publish the present note as some confusion has already arisen between the different varieties.

The Kew Bulletin of Miscellaneous Information, No. 1 of 1913, contains an article on Teff by Mr. Burtt-Davy, Government Botanist to the Union of South Africa. Describing the progress which has been made with Teff in Natal and the Transvaal, incidental reference is made to previous trials in India, notably by Duthie at Saharanpur in 1888. The results given by Duthie were promising, but no further progress appears to have been made; probably for the reason that the Teff was tried as a hot weather and rains crop and possibly also because the wrong variety was obtained. Two varieties of Teff have been tried at Cawnpore, *viz.*, *Teff Tseddia*, obtained from South Africa, and *Teff Hagaiz*, obtained through the kindness of the Director of Kew. A third variety known as Nach Teff appears to exist in Abyssinia, but up to the present the writer has been unsuccessful in attempts to obtain seed.

Of the two varieties tested at Cawnpore *Teff Hagaiz* proved to be useless. It is a variety with a long growing period and failed when grown in the cold weather. Sown in the rains, it took over four months to mature and the yield was not good enough to

justify its cultivation in place of such excellent fodders as ordinary *juar*.

Teff Tseddia, on the other hand, as already mentioned, gave very promising results when sown as an irrigated cold-weather fodder. Seed of this variety is obtainable from the Agricultural Supply Association, Johannesburg, who were recommended to us by the Union Department of Agriculture.

As regards cultivation, Teff grass is suitable for light and medium soils. The South African Department recommend sowing it with a grass drill at the rate of 5 to 7 lb. per acre. At Cawnpore, on land irrigated prior to ploughing, Teff germinated well when sown broadcast at 7 lb. per acre and lightly harrowed in. It is desirable to mix the seed with sand or dry earth to facilitate even distribution. Imported Teff seed is expensive, but good seed is easily saved at Cawnpore. Up to the present seed has been taken from the second cutting only; this was not so bold as the imported seed, but germinated well in the following year and gave a satisfactory crop.

An analysis of Teff hay, kindly furnished by Mr. Clarke, Agricultural Chemist, United Provinces, is inserted for comparison with the Transvaal analysis.

	Cawnpore	Transvaal
	%	%
Water	6·95	8·88
Protein	4·06	6·21
Fat	2·01	1·21
Carbohydrates	51·43	39·08 (Soluble.)
Fibre	29·35	39·07
Ash	6·20	5·55

[B. C. BURT.]

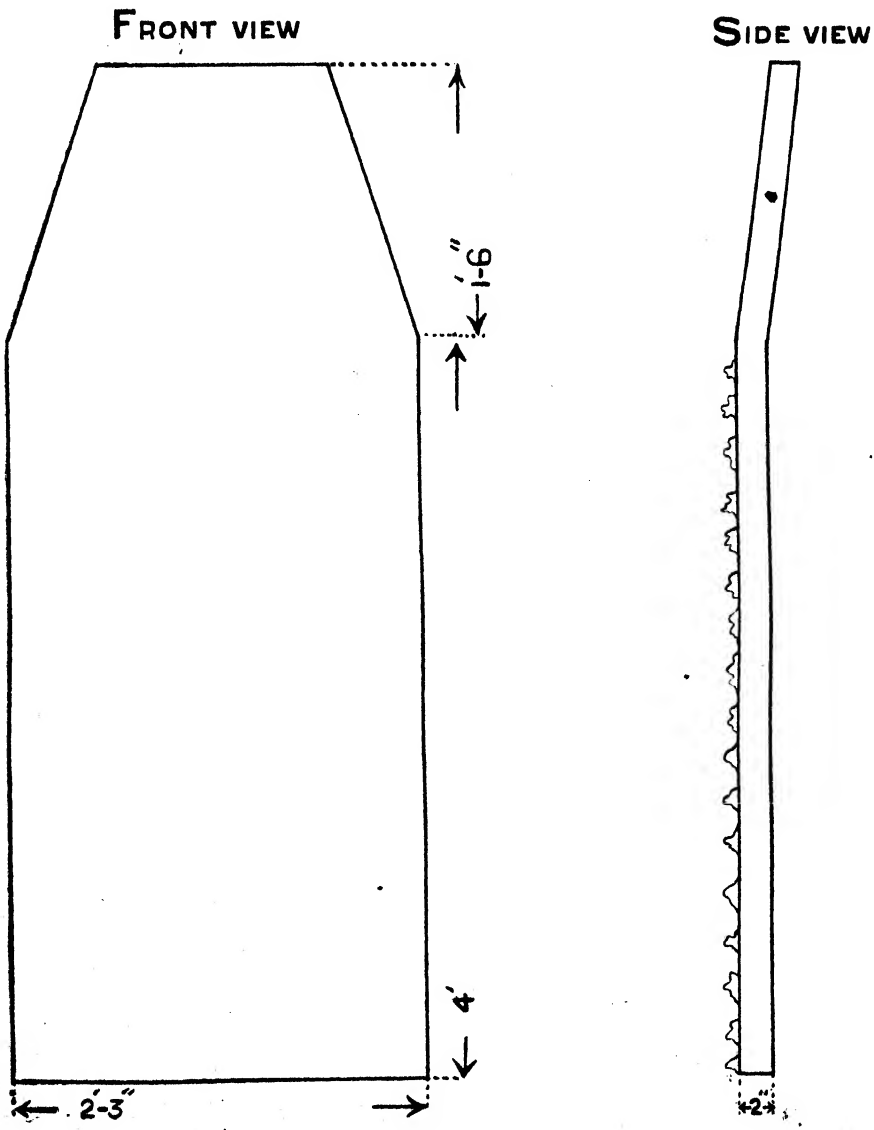
* * *

WE have received from Mr. H. A. Casson, C.I.E., I.C.S., Commissioner, Lahore, for publication the following description of a thresher used in Turkey in Asia which was supplied to him by the Rev. A. E. Harper of Sharakpur.

Plate V shows the thresher at work. Flint stones with sharp edges are fixed on the bottom of the implement, one stone for

THRESHER USED IN TURKEY IN ASIA, AT WORK.

every two square inches and each stone about one inch square and $\frac{3}{16}$th inch thick in centre. The two diagrams below indicate different parts, in detail. The implement is in common use in Turkey in Asia and is considered very efficient. In India iron can be substituted for flint.



Scale. 1 inch=1 foot.

Partial Sterilization of the Soil. A Common Practice in the Shan States. Whilst the work of Russell, Petherbridge, Hutchinson and Pickering (*Journal of Agricultural Science*) has lately proved the value of partial sterilization of the soil by heat and opened the way to further investigation of its effects, a process of soil heating exists as an old established practice throughout the Shan States and is considered indispensable to almost all forms of dry-crop cultivation.

Apart from "Taungya" cultivation, which no doubt owes a very great deal of its success to the sterilization which results from the burning of the dried jungle growth on the surface of the soil before any cultivation takes place, the cultivator of the Shan States assiduously sterilizes his soil for almost every crop which he puts down, but more particularly for hill paddy and for potatoes.

It has been the practice for ages on the extensive red loams or clay-loams—which are derived from the limestone and with which the greater part of the cultivable country is covered—to collect the surface soil into small mounds and to subject it to heat before the crop is planted. The process is going on over large areas throughout the whole of the dry weather.

The surface soil is first loosened to a depth of 2 or 3 inches (seldom more, often less) with a plough drawn by a single buffalo or sometimes by manual labour with a form of hand hoe. The dry lumps are then broken up by beating with a mallet or by the hoe and the soil pulverization completed by further hoeing. The loose soil is then heaped up into small low mounds with crater-like centres—one mound appearing about every 4 feet each way.

The dried vegetation collected on the same land is placed in the "crater" of the heap, but vegetation is extremely scanty and the principal fuel used is dried cattle dung of which a small lump is placed in the centre of each mound. Villages, roads, caravan camping-grounds and even the wide pasture lands are scoured for cattle droppings which are carefully collected, carried to the fields (usually in baskets slung on a yoke over the shoulder) and dried for use in this operation.

When burning is in progress the fuel is allowed to smoulder only and the heaps (of which only a very few are started at the same time) are carefully tended and heaped up so that a maximum of soil may be subjected to the heat. The fuel continues to smoulder for a long time during which the surrounding soil is continually being pulled up on to the top of the heap. On completion the centre of the mound has the appearance of burnt, broken brick. It is surprising what a large amount of soil may be heated in this way with a small amount of fuel and what a large area a single cultivator and his family are able to prepare.

If the land be for paddy, after cooling, the heaps are spread by means of the hoe over the surface of the land, but if intended for potatoes the "sets" are planted in the mounds—three or four small ones in each.

The cultivator believes the process to be essential to the success of his crop, and there is little doubt that by far the greater part of any benefit derived therefrom is due to the heating of the soil, for the amount of manure ashes added is so small as to be almost insignificant.—[E. THOMPSTONE.]

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THE SUPPLY OF AGRICULTURAL IMPLEMENTS BY CO-OPERATIVE SOCIETIES.—Great developments have recently taken place in England and Ireland in the establishment of co-operative societies for the supply of agricultural implements and in many cases societies have been formed especially for this purpose. The system adopted has been for the society to buy from its capital certain implements required by members and to lend these to members on hire. The rates of hire have been fixed high enough to give an appreciable profit and to enable the cost of the implements to be quickly recovered, the receipts so obtained being credited to a general fund with which further implements are purchased as soon as possible. In this way after a few years' working, several of these societies have found themselves in possession of a considerable number of improved implements. And the scheme has not only worked successfully from a financial point of view, but has been of the greatest assistance to members, either by allowing them to bring

larger areas of land under valuable crops, or by enabling them to effect economy in labour.

Agricultural implements may be roughly divided into two classes: those which are merely labour-saving and those which enable cultivation to be carried out more effectively than previously. There is, however, no strict line of demarcation between the two classes as many labour-saving appliances permit of better cultivation by enabling operations to be carried out at the most suitable times.

With small holdings, which are the rule in this province, the demand for expensive labour-saving appliances is necessarily small, but even so, there is a steady demand for such implements as chaff-cutters and improved water-lifts, while there is a larger demand for inexpensive ploughs and cultivating implements which enable cultivation to be carried out more thoroughly than with any indigenous implements. It is obvious that even when freed from debt and placed in a comparatively sound financial position, there are many of these implements which it would hardly pay an individual cultivator to purchase for himself as he would not use them sufficiently often to justify their purchase. On the other hand, there are few village banks which would not benefit by the co-operative ownership of a number of improved implements.

In the past the Agricultural Department has placed small stocks of certain implements at the disposal of central banks for the use of their members. These implements have in some cases been sold direct or given on hire, or in other cases have been sold to members on the instalment payment system. In this way no insignificant number of the cheaper implements, such as Meston ploughs, have been introduced. The arrangement, however, is essentially a temporary one made for demonstration purposes and is one which cannot be indefinitely extended. It is now suggested that certain banks might go a step further and purchase small stocks of implements for the use of their members as well as maintaining a small stock for sale to those members who can afford to buy them. Amongst implements which members might eventually own individually, we may mention such inexpensive implements, as the

Meston plough, but there are far more examples of implements of which one or two would be sufficient for the whole of the village, and which might be given by the village society to its members on hire.

The best example is probably afforded by sugarcane mills and *gur*-boiling pans. That there is considerable profit in this business is evidenced by the fact that throughout this province small agencies are found where iron sugarcane mills are given on hire with or without a *karhao.* The hire charged varies very much, depending partly on the initial price of the mill and partly on the local demand, but it is no uncommon thing to find petty contractors charging as much as Rs. 25 per season for the hire of a sugarcane mill, while in some cases as much as Rs. 40 has been charged. In other villages where mills are given on hire by local men it is frequently the custom to charge Rs. 5 per acre of sugarcane crushed as hire for the *kolhu,* sometimes with and sometimes without the *karhao.* Considering that a very good three-roller mill can be obtained for about Rs. 86, which will last for at least ten years with care, it is obvious that there are considerable profits to be made. Many of the mills given on hire in the bazaar are inefficient and cause a loss varying from one-fifth to one-third of the extractable juice. Such mills can be purchased for Rs. 25 to Rs. 30, but a little consideration will show that, apart from the fact that they frequently get out of repair, a mill of this kind is dear at any price. It would be quite a feasible proposition for a central bank to own (say) 20 first-class three-roller sugarcane mills and to give these on hire to village societies for the use of their members. The central bank would generally be in a position to make arrangements for the annual overhauling of the mills and the re-turning and re-grooving of the rollers; but should any difficulty arise the Agricultural Department could assist them in this matter. It would also be necessary for the central bank to maintain a small stock of spare parts, so that mills might be kept in order, and it would also be desirable that they should keep during the crushing season an ordinary *mistri,* who could go round and see that the mills were kept in adjustment and were not being mishandled.

Another agricultural implement, in this case really labour-saving, which has caught on throughout the province is the chaff-

cutter, but here again it is obvious that only a man possessing five or six pairs of cattle can make it worth while to own one himself and most of the chaff-cutters sold through the Agricultural Department are being supplied to cultivating zemindars, many of whom also give facilities for their use to their cultivators. A chaff-cutter costing from Rs. 40 to Rs. 50 is capable of cutting sufficient fodder for 15 to 20 pairs of cattle; it is obvious, therefore, that one or two chaff-cutters would meet the requirements of a single village society. It should not be beyond the powers of a flourishing village society to work out a hire scheme, by which a jointly-owned chaff-cutter could be used by all the members. Assuming a society to consist of 20 members each owning a pair of bullocks, a fee of annas four per month throughout the year would more than pay for the chaff-cutter in a single year, whilst a fee of annas four per month restricted to the *chari* and *karbi* season would enable the chaff-cutter to be paid for in two years and would leave a handsome margin for the provision of new knives when required and to meet any repairs necessary.

As a third example may be quoted the case of special ploughs. It has already been suggested that the ordinary Meston plough is sufficiently cheap to enable individual members to own it, though there will be no objection to a few such ploughs also being jointly owned by small village societies, where the holdings are small. In the case of larger ploughs and special purpose ploughs, for details of which reference may be made to the pamphlet on ploughs and ploughing, published by the Department of Agriculture, United Provinces, one or two ploughs would probably be sufficient for a village bank. These ploughs vary in price from Rs. 25 to Rs. 50 and, as in the case of the chaff-cutter, a very modest rate of hire would soon bring in enough money to pay for the plough. In certain districts, for example, large ploughs are required for ploughing out deep-rooted weeds, such as *bainsura* and *kans*. Experiment has shown that if these weeds can once be got under by thorough ploughing, their complete eradication is merely a matter of time and patience, but ordinary cultivators do not possess the means of deep ploughing and their only alternative is the very expensive process of digging by hand. With one large plough in a

village, owned co-operatively, small areas could be done each year until the pest was eradicated, whilst in the case of ploughs requiring more than one pair of bullocks the co-operative ownership of the plough would stimulate members to help each other by the loan of bullocks in turn. Another plough may be mentioned, which although not heavy to work it, is expensive to buy, *viz.*, the steel-bar-point plough (Pathartor or Sabul plough), which can be used for breaking up hard land without irrigation. By using such ploughs it is possible, even when there is no rain, to plough cotton and *juar* stubbles during the cold weather, thus improving the yield in the subsequent year and doing much to eradicate insect pests. It would be easy to multiply instances of improved agricultural implements which might be owned co-operatively. A new list of implements with prices has been published by the Agricultural Department, United Provinces, and it is for co-operative banks to select those which meet their requirements. The object of the present paper is to point out the great possibilities the co-operative ownership of implements opens up.

In conclusion, stress may once more be laid on the principle which was enunciated in connection with the establishment of co-operative seed stores, *viz.*, that all such transactions must have a cash basis, and further that members obtaining seed or implements from either a village society or a central bank must be just as prompt in payment of their dues—whether for price or for hire—as in the repayment of cash loans. This has not always been understood in the past where the Agricultural Department has supplied seed or implements to central banks for the benefit of the constituent societies. Any slackness in this respect is opposed to the fundamental principles of co-operation, and it is, therefore, necessary that managers and *sarpanches* should insist on the same scrupulous care in the repayment of money due for seeds or implements as in the case of cash loans. It is also desirable that central banks should adequately realize their responsibilities in such matters.—[B. C. BURT.]

Note.—This paper was originally read in vernacular at the Co-operative Conference held at Lucknow in February 1916. It is

somewhat of local interest, but it was impossible to remedy this without recasting the whole paper. It is, however, published here in the hope that it may prove of some utility to workers in the same field in other provinces.

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SALE OF MANURES BY CO-OPERATIVE SOCIETIES.*—The extent to which the use of certain manures, chiefly cakes, such as castor cake and *nim* cake, is growing in those parts of the provinces where intensive cultivation is carried on, is not fully realized. For instance, castor cake is very widely used for potato-growing round Fatehgarh and is gradually extending beyond the borders of the Cawnpore District. In parts of the Meerut District *nim* and castor cake are popular for potato-growing and for chewing-cane. One cultivator, in the latter area, informed the writer that he had spent about Rs. 50 on manuring his cane field with castor cake, and he found that it amply paid him to do so. Intensive cultivation for the production of vegetables, etc., is spreading round the large towns and would undoubtedly increase more rapidly but for the difficulty in procuring manures, without which it cannot be carried on. Some of the large towns, such as Cawnpore and Benares, dispose of their sewage by putting it into the nearest river; while in many of the smaller towns little use is made of the available supply, owing to objections in handling it. The market for the sale of manurial cakes, such as those mentioned above, is at present very imperfectly organized; prices fluctuate largely and sometimes it is by no means easy to procure them at all. Much of the castor cake pressed in these provinces is under normal trade conditions exported; though judging from the quoted prices, there is very little, if any, more profit to be obtained from the export than from internal trade. The crushing of *nim* for oil seems to be almost entirely a village industry and, while the cake is cheap in some parts of the provinces, it is almost unprocurable in others. The Agricultural Department, though willing to pay good prices for these cakes for sugarcane growing, often find it difficult to buy them, owing to the lack of organization

* A paper read at the Provincial Co-operative Conference held at Lucknow in February 1916.

in the market. Looking to the small quantities of poudrette procurable and the objections that many cultivators have to using it, these cakes seem to offer one of the best forms of manure for common use. They possess in varying degrees the valuable constituent of nitrogen, which is mainly required in the soils of these provinces, and they are far cheaper than what are ordinarily known as artificial fertilizers. An attempt is also being made to popularize the use of these cakes from another point of view. There is a very large export trade in oil-seeds from these provinces, and there is *primâ facie* no reason why some portion should not be crushed in these provinces and a valuable industry thereby opened up. Many of these oil-cakes form valuable feeding stuff for cattle, while some, such as *mohwa* cake, should be useful for manure. The difficulty however in starting such industry has hitherto been the absence of a regular market for the cake, without which it does not pay to crush. A grant has recently been made by Government for popularizing the use of these cakes and the greater part of the grant is being devoted to putting out manurial cakes, principally *mohwa*, the use of which is little known in these provinces. In some instances the cake is being distributed through co-operative societies to their members. If it is appreciated, the foundation should be laid for a regular sale of this cake, which is now procurable in fairly large quantities, to cultivators. This will serve the two-fold purpose of establishing an industry and providing a means for improving the cultivators' crops. The need for some regular supply association for the provision of these manurial cakes has already been pointed out. If, as is to be sincerely hoped, their use becomes more common, the co-operative societies could very well undertake their sale. In Europe the supply of manures is one of the largest business of the agricultural co-operative societies, and it is a very profitable one to the societies. There is a wide margin between wholesale and retail rates, and the manufacturer is generally willing to sell cheaper in large quantities. It may be mentioned that a firm engaged in oil crushing in these provinces offered to sell *mohwa* cake at 2½ annas per maund, instead of 4 annas, if taken in quantities of over 10,000 maunds. This would permit the society

to sell below market rates and still retain a handsome profit. In other parts of India rather more progress seems to have been made. At the last meeting of the Board of Agriculture it was stated that "In the case of manure societies, a notable success has been achieved at Kelva Mahim near Bombay where in a tract of very intensive culture, with a large demand for castor cake, the first year's operations, on the basis of a co-operative capital of Rs. 7,500, a profit of 25 per cent. has been secured and the cake sold below the market rate. It has secured also that the market rate has been much lower than it would have otherwise been. In this case the co-operators were almost exclusively the gardeners themselves, but the management was in the hands of a keen local man, not however a gardener. A larger manure supply society has recently been promoted in one of the sugarcane tracts in the Deccan, with a capital of Rs. 20,000. It has succeeded in coming out satisfactorily from the first year's trading, though there will be no large actual profit, but it has caused the price of fish-manure (in which it dealt) not to rise as was invariably the case in former years. The result of its experience is to indicate that such a society is best run when the shareholders are co-operative credit societies who can buy for the benefit of their members rather than individual cultivators."

If, as may be hoped will be the case, the steps taken this year lead to a more general demand for cake for manurial purposes, some of the co-operative societies working in tracts where intensive cultivation prevails might find it worth their while to start on this business. They can be assured of every assistance from the Department, and most probably they will find the larger manufacturer anxious to meet them half-way in the matter of prices. It need scarcely be said that no such step is to be recommended, unless a good sale is practically assured; but, where potato-growing is already well established, the market exists on a considerable scale and will probably rapidly expand. In such areas a special society for the provision of manures might prove feasible, and is likely to prove a boon to the cultivators. The writer has conversed with some of the cultivators in the Cawnpore District and finds that the potato trade is growing, and there is a big export business to other parts

of the provinces. Some are able to obtain village refuse for their fields; but a considerable number use castor or *nim* cake. These cakes are also occasionally used for tobacco-growing; but as a rule this crop is only grown on the fields immediately adjoining the village site. In time it may be hoped that our cultivators will follow the example of those of Bombay and liberally manure the sugarcane grown for the manufacture of *gur*. At the present prices of *gur* it would amply pay them to do so.

Apart from the areas which specialize in garden crops, openings for the sale of manures may be anticipated in another direction. When the societies which have already been formed to supply water to their members begin to work, the writer feels assured that a demand for manures will spring up. The immediate result of a regular supply of water—at times when it is wanted—is the putting down of a better class of crops, and the growing of special crops, such as chewing-cane, vegetables, etc. These require manure and it is very soon found that it pays to apply it. In one district, arrangements are being made for the sowing of castor as a border crop in order to provide a regular supply of cake. It is believed that in a few years' time those societies which can supply water will find themselves called upon to supply manure also; and that they will find it a profitable business with small risks.—[H. R. C. HAILEY.]

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THE MATERIAL BASIS OF CO-OPERATIVE CREDIT.*—The credit of any individual person rests partly upon the amount and value of his property, and partly upon his character and reputation for success or failure in his agricultural or business undertakings. His credit, we may say, can rest either upon a *material* basis or upon a *personal* basis. It is the essence of the co-operative credit movement that by incorporation with joint unlimited liability the personal credit of a group of persons becomes very greatly strengthened. This outstanding fact does not, however, diminish

* A paper read at the Provincial Co-operative Conference held at Lucknow in February 1916.

the need or advantage of developing credit with a material basis, *i.e.*, credit based on the property of the borrowers, as an additional support.

Personal credit must always be somewhat weak, even when it is joint among thirty or more members, especially in India. The danger arises from the fact that a widespread natural calamity, such as drought or flood, can affect simultaneously in a similar way at the same time all members of a society. At such times of trial societies are liable to break up through dissensions. Hence it is to the interest of every member not only to strengthen his own material credit, but also to see that other members strengthen theirs.

The building up of material credit must necessarily be a slow process. It is to be done by accumulating productive property—land, cattle, good ploughs, carts, and other tools and implements, and by improving the land with drainage or fencing, or sometimes with silos, grain pits or *pucca* buildings for co-operative or individual purposes. Another very important way of increasing material credit is by improving the methods of cultivation, for the cultivator is thus assured of producing a larger income and he obtains a larger margin over his bare expenses of living. It is of most vital importance that every member should see that every other member is carrying out his cultivation properly and is marketing by the most economical methods. Every member should learn to say to himself:—"My fellow-member's profit is my own safety."

Not only farm implements, buildings and better cultivation, but also immaterial property rights, such as good and long leases, or possession of occupancy rights, are important bases of security; and every society should do its utmost both to protect its members in the continued enjoyment of such rights, and to secure new rights for them whenever possible. Except when the past record of a zemindar gives a practical guarantee against unreasonable disturbance, the policy followed by some societies which consist almost wholly of members possessing occupancy rights, of restricting the admission of new members to candidates possessing occupancy rights would seem to be sound. This policy should certainly not

be discouraged even though it may lead to individual cases of hardship amongst cultivators unable to acquire occupancy rights.

Although rights of tenure are of great importance as a basis of credit, at the present time the main basis of improved credit of rural societies must be the adoption of better methods of cultivation and the accumulation of property. Some of the property, such as ploughs and the smaller implements, must be owned individually ; but many things, such as seed stores, oxen, machines, grain or silage pits, wells, and so forth, should be co-operatively owned, that is to say, they should belong to the society and the oxen and machines should be hired out according to a pre-arranged plan. The question may well be asked whether some part of the reserve funds—not the whole—might not with propriety and advantage be invested in durable machines or in improvements of a lasting character, such as wells, irrigation channels, grain pits, drainage works, fencing and so forth wherever security of tenure for such works can be obtained from the zemindar.

If the three means of increasing material credit be steadfastly pursued—that is to say : better cultivation, accumulation of productive property, and acquisition of tenancy or proprietary rights—the credit of co-operative societies will be so greatly increased that it will be possible considerably to reduce the rates of interest at which cultivators borrow from societies. By taking the necessary steps to increase their material credit they will have learnt to value capital property, for they will know its productive capacity. Having larger incomes, and being able to borrow at lower rates, they will be able to borrow much larger sums to be applied in still further improving their methods of cultivation and the area cultivated. Thus there may be gradually brought about, through taking proper steps to increase the material basis of co-operative credit, a general raising of the standard of life of all members of the societies.—[H. Stanley Jevons.]

REVIEWS.

Preliminary Note on Sheep-breeding Experiments by the Civil Veterinary Department, United Provinces.—BY E. W. OLIVER, M. R. C. V. S., F. Z. S., Superintendent, Civil Veterinary Department, United Provinces. Printed at the Anglo-Oriental Press, Lucknow, 1915.

THIS pamphlet briefly describes the sheep-breeding experiments at present in progress in the United Provinces. Attempts were made in India from time to time since 1825 to improve the breeds of Indian sheep, but they met with little success mainly on account of two reasons, *viz.*, absence of any sound, scientific, or systematic basis and want of continuity in operations. No regard was paid to the choice of localities and the methods of breeding, resulting generally in the ultimate return of the features of the progeny to those of the prepotent indigenous parent. It seems to have been thought sufficient to merely import rams of a famous breed, without regard to dissimilarity of the pasturage, water, climate, and other conditions in India to that of their natural home and little or no attention seems to have been paid to the most important point of all, *viz.*, the selection and suitability of the indigenous ewes and the intelligent mating of the progeny.

The Civil Veterinary Department, United Provinces, seriously took up the subject of sheep-breeding in 1912. Several Australian sheep raisers as well as wool experts were consulted with a view to obtain the soundest information and help in the matter. After taking a survey of the present sheep-breeding tracts of the province, experimental work has been started at ten centres. One of the main objects of these experiments is to "evolve and fix a breed of sheep of superior wool-growing and flesh-forming capacity which would

eventually breed true to type and at the same time be able to withstand the vicissitudes of Indian climate and other adverse conditions." A system of grading up from carefully selected indigenous ewes by crossing them with rams of superior wool-producing breeds was considered the soundest plan to follow. With this end in view indigenous ewes were crossed with specially imported New Zealand Merinos and a few of the Riverina rams.

Having obtained half-breds the following experiments are now in progress :—

(*a*) Crossing the half-bred Merino ewe with pure Merino ram.
(*b*) Mating half-bred Merino rams and ewes together (unrelated strains).
(*c*) Crossing the native ewes with half-bred Merino rams.

It is from (*a*) and (*b*) that the best results are anticipated.

The results so far obtained are satisfactory. The half-bred Merinos yield 5 to 6 lb. of wool per animal per year, whereas the yield of the native sheep of the province rarely reaches 2lb. The former has also been highly spoken of by wool experts and the Cawnpore Woollen Mills purchased it at 8 annas per lb. when the country wool fetched only 4 annas per lb. The author recommends that shearing should take place twice in a year, *viz.*, in March and September, and deprecates the practice of three shearings at present in vogue in the province. As a result of experiments it has been found by the author that in India also, judicious and periodical dipping of sheep is very beneficial to the fleece as well as to the general health of the animal. Among the difficulties attending sheep-breeding experiments on improved lines are the somewhat large mortality of the imported stock owing to the extreme change of climate, the prevalence of epizootics and parasitic diseases. Even the indigenous sheep are not altogether immune to these scourges. It is hoped, however, that the graded up progeny will acquire from the native parent or grand-parent a degree of immunity to the effects of climate and to certain of the most dangerous sheep diseases.

The proper handling of sheep and wool including careful methods of shearing, dipping, and packing of fleeces, etc., is practically unknown to Indian shepherds. The appointment of a young Australian who has had a thorough experience of this work is therefore recommended.

The experiments are full of promise and we await the further results with interest.—[EDITOR].

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Mysore Agricultural Calendar, 1916.— Published by the Department of Agriculture, Mysore. Government Press. Bangalore. Price 1 anna.

THIS Calendar seems to have been prepared on the lines of the Madras Agricultural Calendar. It opens with a short account of the progress made by the Agricultural Department, Mysore, during the year 1915, in which the point most deserving notice is the inauguration from the beginning of the current year, of the system of selling improved implements to ryots on an easy instalment system of payment. As this is an interesting experiment some of the conditions under which this system is worked are here given for the information of the readers of this Journal. The value of implements sold to any one ryot or landholder under these rules and outstanding against him at any one time is not to exceed Rs. 2,000, the rate of interest charged being 5 per cent. per annum. An agreement in the prescribed form has to be executed and a deposit of one-fourth of the value of the implements to be made before the supply is sanctioned. The period of payment of instalments is fixed at three years in the case of implements costing Rs. 100 or less and five years in all other cases. All sums falling due under these rules are recoverable as arrears of land revenue, a stipulation to this effect being inserted in every agreement executed by the hirer. Besides the ordinary calendar, monthly notes containing useful hints to cultivators are given below the calendar for each month. It also contains small articles on (1) the New Bar-Share plough; (2) Potato Cultivation; (3) Smut on Jola (*Andropogon Sorghum*); (4) Kondali Hula (*Ophiusa*

meliceerte) on Castor; (5) Co-operative Credit in Mysore; (6) The Rice-case Worm; (7) Foot and Mouth Disease; (8) Cattle Manure: How best to collect and conserve it; and (9) Manuring of Sugarcane. In short, it may be said that the present Calendar and the one for the previous year contain much useful information, and as these are also published in the vernacular, information given therein will not fail to reach those for whom it is intended and this will no doubt considerably facilitate the work of the Department.—[EDITOR].

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1st AUGUST, 1915, TO 31st JANUARY, 1916.

No.	Title	Author	Where published
	GENERAL AGRICULTURE.		
1	*The Agricultural Journal of India*, Vol. X, Part IV., and Vol. XI, Part I. Price per Part, Rs. 2; annual subscription, Rs. 6.	Issued from the Agricultural Research Institute, Pusa, Bihar.	Messrs. Thacker, Spink & Co., Calcutta.
2	Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for 1914-15. Price, As. 8 or 9*d*.	Ditto.	Government Printing, India, Calcutta.
3	Green-Manuring in India, Bulletin No. 56 of the Agricultural Research Institute, Pusa. Price, As. 6 or 7*d*.	A. C. Dobbs, B.A., Imperial Agriculturist.	Ditto.
4	Agriculture in India. Price, As. 4.	James Mackenna, M.A., I.C.S.	Ditto.
5	Proceedings of the Inter-Provincial Jute Conference held at Calcutta, from 2nd to 4th August 1915. Price, As. 6 or 7*d*.	......	Ditto.
6	Report of the Committee on Co-operation in India.	......	Government Central Press, Simla.
7	Annual Report of the Department of Agriculture, Bengal, for the year ending 30th June 1915. Price, As. 7.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book Depôt.
8	Annual Report of the Expert Officers (Bengal) for the year ending 30th June 1915. Price, Rs. 1-12-0.	Ditto.	Ditto.
9	Potato Cultivation (in Bengali) Bulletin No. 2 of 1915 of the Bengal Department of Agriculture (for free distribution).	Ditto.	Ditto.
10	Annual Report of the Department of Agriculture, Bihar and Orissa, for 1914-15. Price, As. 8 or 9*d*.	Issued by the Department of Agriculture, Bihar and Orissa.	The Bihar and Orissa Government Press, Patna.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
11	Report on the Agricultural Activities of Government in Bihar and Orissa for the year 1914-15. Price, R. 1 or 1*s*. 6*d*.	Issued by the Department of Agriculture, Bihar and Orissa.	The Bihar and Orissa Government Press, Patna.
12	Season and Crop Report of Bihar and Orissa for 1914-15. Price, As. 6 or 6*d*.	Ditto.	Ditto.
13	*Agricultural Journal* (Published half-yearly). Price, R. 1 per annum.	Ditto.	Ditto.
14	Report on the Administration of the Department of Agriculture, United Provinces of Agra and Oudh, for the year ending 30th June, 1915. Price, As. 8 or 9*d*.	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
15	Report on the Cawnpore Agricultural Station for the year ending 30th June 1915. Price, R. 1 or 1*s*. 6*d*.	Ditto.	Ditto.
16	Report on the Atarra (Banda) Experimental Station for the year ending 30th June 1915. Price, As. 6 or 6*d*.	Ditto.	Ditto.
17	Report on the Agricultural Station Orai (Jalaun) for the years ending 30th June 1914 and 1915. Price, As. 6 or 6*d*.	Ditto.	Ditto.
18	Report on the Partabgarh Agricultural Station for the year ending 30th June 1915. Price, As. 8 or 9*d*.	Ditto.	Ditto.
19	Report on the Agricultural Stations of the Western Circle of the United Provinces for the year ending 30th June 1915. Price, As. 8 or 9*d*.	Ditto.	Ditto.
20	A brochure on School Gardens. Bulletin No. 34 of the Department of Agriculture, United Provinces. Price A. 1 or 1*d*.	H. J. Davies, F.R.H.S., Superintendent, Government Horticultural Gardens, Lucknow.	Ditto.
21	Annual Report of the Department of Agriculture, Punjab, for the year ending 30th June 1915. Price, As. 11 or 1*s*.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
22	Season and Crop Report of the Punjab for the year 1914-15. Price, As. 9 or 9*d*.	Ditto.	Ditto.
23	Catalogue of Ploughs and other Agricultural Implements recommended by the Punjab Agricultural Department (in Urdu) illustrated, 1915—(for free distribution).	Ditto.	Civil and Military Gazette Press, Lahore.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
24	Season and Crop Report of the Bombay Presidency for 1914-15. Price, As. 4 or 5*d*.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
25	Indigenous Implements of the Bombay Presidency. Bulletin No. 66 (1914) of the Department of Agriculture, Bombay. Price, Rs. 2-2-0 or 3*s*.	Rao Saheb G. K. Kelkar, Acting Deputy Director of Agriculture, Bombay Presidency.	Ditto.
26	Grape Growing in the Nasik District. Bulletin No. 71 (1915) of the Department of Agriculture, Bombay. Price, As. 9 or 10*d*.	H. V. Gole, Nasik	The Yeravda Prison Press, Poona.
27	Experiments with the Automatic Water Finder in the Trap Region of Western India. Bulletin No. 72 (1915) of the Department of Agriculture, Bombay. Price, As. 4 or 5*d*.	H. H. Mann, D.SC., Principal, Agricultural College, Poona.	Ditto.
28	Season and Crop Report of the Madras Presidency for 1914-15. Price, As. 4 or 6*d*.	Department of Agriculture, Madras.	Government Press, Madras.
29	Report of the Work of the Samalkota Agricultural Station for 1914-15. Price, As. 2½ or 3*d*.	Ditto.	Ditto.
30	Pulichai, Mailam, or Jari cotton in Tinnevelly and Ramnad Districts. Leaflet No. 4 (1915) of the Department of Agriculture, Madras	D. T. Chadwick, I.C.S., Director of Agriculture, Madras.	Ditto.
31	Water Hyacinth. Leaflet No. 5 (1915) of the Department of Agriculture, Madras.	Ditto.	Ditto.
32	List of Agricultural Implements recommended by the Department. Leaflet No. 7 (1915) of the Department of Agriculture, Madras.	Ditto.	Ditto.
33	Method of Collecting and Dressing *Kolinji* Seed before Sowing. Leaflet No. 8 (1915) of the Department of Agriculture, Madras.	J. Chelvaranga Razu	Ditto.
34	Report on the working of the Department of Agriculture, Central Provinces and Berar, for 1914-15. Price, R. 1.	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.
35	Report on the Management of the Provincial and District gardens, Central Provinces and Berar for 1914-15. Price, As. 4.	Ditto.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
36	Report on Agricultural Stations in Southern Circle, for 1914-15. Price, R. 1.	Issued by the Department of Agriculture. Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.
37	Report on Agricultural Stations, Northern Circle. Price, R. 1.	Ditto.	Ditto.
38	Report on Agricultural Stations, Western Circle. Price, As. 8.	Ditto.	Ditto.
39	Report on the Experimental Farm, Nagpur, for 1914-15. Price, As. 8.	Ditto.	Ditto.
40	Report on Demonstration Work in Southern Circle, for 1914-15. Price, As. 8.	Ditto.	Ditto.
41	Report on Demonstration Work in Northern Circle. Price, As. 8.	Ditto.	Ditto.
42	Report on Demonstration Work in Western Circle. Price, As. 8.	Ditto.	Ditto.
43	Report on Agricultural College, Nagpur, Botanical and Chemical Research, Central Museum, Nagpur, and Maharajbagh Menagerie for 1914-15. Price, As. 8.	Ditto.	Ditto.
44	*The Agricultural and Co-operative Gazette* (monthly) from August 1915 to January 1916. Price, As. 2 per issue.	Ditto.	Shalam Press, Nagpur.
45	Report on the Operations of the Department of Agriculture, Burma, for the year ending 30th June 1915. Price, As. 6 or *7d.*	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
46	Report of the Agricultural Stations of the Southern Circle for the year 1914-15. Price, As. 4 or *5d.*	Ditto.	Ditto.
47	Report of the Third Agricultural and Co-operative Conference, Burma (English and Burmese). Price, As. 6.	Ditto.	Ditto.
48	Burmese equivalents for terms connected with Agricultural Science. Occasional Papers No. 2 of the Department of Agriculture, Burma.	Ditto.	Ditto.
49	Note on Formation of Bamboo Plantations. Cultivators' Leaflet No. 45 of the Department of Agriculture, Burma (for free distribution).	Ditto.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
50	Report of the Department of Agriculture, Assam, for the year ending 30th June 1915. Price, As 8 or 9*d*.	Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
51	Annual Report of the Jorhat Agricultural Experiment Station for the year ending 30th June 1915.	Ditto.	Ditto.
52	Annual Report of the Kamrup Sugarcane Experiment Station for the year ending 30th June 1915.	Ditto.	Ditto.
53	Annual Report of the Upper Shillong Agricultural Station for the year ending 30th June 1915.	Ditto.	Ditto.
54	Annual Report of the Karimganj Agricultural Experiment Station for the year ending 30th June 1915.	Ditto.	Ditto.
55	Annual Report of the Agricultural Experiments and Demonstrations in Assam for the year ending 30th June 1915.	Ditto.	Ditto.
56	Annual Report of the Fruit Experiment Station, Shillong, for the year ending 30th June 1915.	Ditto.	Ditto.
57	Preserving Fodder for Winter in the Khasi Hills (in Khasi). Bulletin No. 1 of 1914 of the Department of Agriculture, Assam.	Ditto.	Ditto.
58	Potato Cultivation in the Assam Hills (in Khasi). Bulletin No. 3 (1914) of the Department of Agriculture, Assam.	Ditto.	Ditto.
59	Bone Meal as Manure for Wet Rice Lands in the Khasi and Jaintia Hills (in Khasi). Leaflet No. 3 (1914) of the Department of Agriculture, Assam.	Ditto.	Ditto.
60	The Cultivation of Sugarcane (in English, Bengali, and Assamese), Bulletin No. 1 (1915) of the Department of Agriculture, Assam.	Ditto.	Ditto.
61	Iron Sugarcane Mills (in English, Bengali, and Assamese) Leaflet No. 2 (1915) of the Department of Agriculture, Assam.	Ditto.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—concld.		
62	Some better varieties of Sugarcane for the Assam Valley (in English, Bengali, and Assamese). Leaflet No. 3 (1915) of the Department of Agriculture, Assam.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
63	Potato Cultivation in the plains (in English, Bengali, and Assamese). Leaflet No. 4 (1915) of the Department of Agriculture, Assam.	Ditto.	Ditto.
64	Fodder Crops (in English, Bengali, and Assamese). Leaflet No 5 (1915) of the Department of Agriculture, Assam.	Ditto.	Ditto.
65	Annual Report of the Peshawar Agricultural Station at Tarnab in the North-West Frontier Province for the year ending 30th June 1915.	Issued by the Department of Agriculture, North-West Frontier Province.	Messrs. Thacker, Spink & Co., Calcutta.
66	Annual Report of the Department of Agriculture, Mysore, 1914-15.	Issued by the Department of Agriculture, Mysore.	Government Press, Bangalore.
67	Mysore Agricultural Calendar, 1916. Price, 1 anna.	Ditto.	Ditto.
68	The *Journal of the Madras Agricultural Students' Union* (monthly). Annual Subscription R. 1.	Madras Agricultural Students' Union.	Literary Sun Press, Coimbatore.
69	*Quarterly Journal of the Indian Tea Association.* Price, As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
70	*Indian Poultry Gazette* (monthly). Subscription Rs. 3 per annum.	Indian Poultry Club, Lucknow.	Mafasilite Electric Printing Works, Mussoorie.
71	*Poona Agricultural College Magazine* (quarterly). Annual Subscription Rs. 2.	College Magazine Committee, Poona.	Arya Bhushan Press, Poona.
	AGRICULTURAL CHEMISTRY.		
72	Soil Gases. Memoirs of the Department of Agriculture in India, Chemical Series, Vol IV, No. 3. Price, Rs. 1-8-0 or 2*s*. 6*d*.	J. W. Leather, V.D., F.I.C., Imperial Agricultural Chemist.	Messrs. Thacker, Spink & Co., Calcutta.
73	The Detection of Added Water in Milk in India. Bulletin No. 57 of the Agricultural Research Institute, Pusa. Price, As. 2 or 3*d*.	Ditto.	Government Printing, India, Calcutta.
74	Well Waters from the Trap Area of Western India. Bulletin No. 74 (1915) of the Department of Agriculture, Bombay. Price, As. 6 or 7*d*.	H. H. Mann, D.Sc., Principal of the Agricultural College, Poona.	The Yeravda Prison Press, Poona.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	MYCOLOGY.		
75	The Genus *Rhizoctonia* in India. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VII, No. 4. Price, R. 1 or 1*s*. 6*d*.	F. J. F. Shaw, B.Sc. and S.L. Ajrekar, B.A.	Messrs. Thacker, Spink & Co., Calcutta.
76	Bordeaux Mixture as a preventive of Potato Disease. Bulletin No. 2 of 1914 of the Department of Agriculture, Assam (in Bengali, Assamese, and Khasi).	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
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PLATE VI.

ERRATA.

(*i*) *Vol. XI, Part I, of this Journal.*

In the article on "Indian Hemp Fibre," pp. 31—41, substitute "Sann-hemp" *for* "Indian hemp" wherever it occurs.

(*ii*) *Special Indian Science Congress Number of the Journal.*

Page 96, 4th line from bottom. For "to evaluate time" *read* "time to evaluate."

AGRICULTURAL MUTUAL CREDIT IN FRANCE AND THE WAR.

[We extract the following from an article by G. Louée in the *Bulletin des Syndicats agricoles du Jura*. It was these *Syndicats agricoles* that rendered easy the payment of the indemnity in the Franco-Prussian war. It is the spirit of these *Syndicats agricoles* that will enable our allies, with us, to win this great world war: it is the spirit of these *Syndicats agricoles* that, after the war, will raise a greater, a more prosperous, and a more glorious France.—(Editor.)]

"The action of the Regional Bank of Mutual Credit of Burgundy and Franche-Comté during the war may be summarised as follows:—At the beginning of the war, the total deposits for which the Regional Bank and the local banks were responsible amounted to the sum of two and a half million francs. The deposits belonged to about 3,000 individuals, all small capitalists and thrifty cultivators, who, having accumulated a small sum of money by dint of toil, were the more liable to the fears that might take possession of the public at the beginning of hostilities.

"These societies found themselves in the same position as the Savings Banks and other institutions of credit that were in direct contact with the savings of the people, and like these they were liable to see their clients insist upon their deposits being refunded.

"Their situation, however, has been quite different: no demands have been made for repayment: there was no need for a moratorium. They have even received, since the beginning of the war, new deposits of the total value of 120,000 francs.

"In the country districts, the people are only too much inclined to believe that debts need not be paid during the war, and one might be inclined to predict that the repayment of small debts would be

suspended, the moratorium having, moreover, deferred the time of their falling due to an undetermined date.

"The agricultural credit institutions of Burgundy and Franche-Comté have upset the least pessimistic forecasts of this kind and proved themselves capable of facing the most critical situations. In fact, the Regional Bank, seeing that the cultivators were realising large sums on account of the requisitions and the rise in the prices of the products of the soil and of cattle, insisted on the local banks obtaining at least partial, if not complete, repayment, whenever the condition of the borrowers permitted it, without in any way involving in difficulties the families of the men mobilised. Since the beginning of the war the sum of 434,000 francs has been received under the head of repaid loans.

"With the deposits entrusted to it, and the repaid loans *plus* the sum standing to its credit with its banker at the beginning of the year and which the banker paid into it, the Regional Bank has bought over 900,000 francs worth of Treasury bonds."

THE HAND-FEEDING AND MANAGEMENT OF BUFFALO CALVES AT A DAIRY.

BY

ROBERT G. ALLAN, M.A.,

Principal, Agricultural College, Nagpur;

AND

J. V. TAKLE, L.Ag., N.D.D.,

College Dairy Overseer, Nagpur.

CALF raising, though frequently neglected or carelessly carried out, is an important section of dairy management. The importance of the subject is proportional to the milk capacity of the individual buffaloes and cows forming the herd; to the difficulty of procuring, by purchase, substitutes in their place and to the money value which is likely to be got for such animals as it is necessary to sell from the herd. Dairying on modern lines, with due care to hygienic conditions and purity, cannot be worked at a profit by filling up a herd with inferior low-yielding animals and by depending on the number of animals rather than on the quality of the individual for the necessary bulk of milk. When the animals of a dairy herd are individually poor there is little scope for or inducement to the careful raising of the progeny. On the other hand, good milkers are comparatively rare and the present system in many dairies of making no real attempt to raise the calves properly and of depending on the purchase of milk stock from external sources is creating a drain on the supply of good milkers (for example the Sindhi breed of Karachi and the Murrah buffalo of Delhi) and raising the price without any adequate effort to repair or replace the loss to which the milk interests of the future are being subjected.

Given that a foundation herd of carefully selected good milkers is established, due attention to the raising of the progeny, in particular the progeny destined to extend the herd or replace its older members, is both desirable and profitable. A herd which is dependent on purchases for extension and replacement can never really hope to make that definite improvement in individual milk production which is the foundation of profitable dairying. At the same time the chances of the introduction of disease into the herd are much greater in one based on purchase than in one based on home breeding and raising. If it is intended that the future stock be raised in the dairy, the raising must be carefully done. Otherwise the death-rate among the calves will be high and such as come to maturity will fail to maintain the milk producing level of their dams. In the writers' opinion a very fair proportion of the blame for the low yield of Indian buffaloes and cows is to be attributed to the wretched conditions of food and care under which they are raised during the first 7-8 months of their lives, as young calves. It is commonly remarked that she-buffaloes raised in big dairies have seldom, if ever, the milk production of purchased buffaloes from up-country. This is entirely due to the lack of care and sufficient food generally given to calves at such centres. In the writers' opinion and experience, home-raised Delhi buffaloes will give an equal or even better production than their dams, provided a certain amount of care is given in the earlier months of their existence. They can be raised as satisfactorily, if not more so, on a diet of separated milk and a proper substitute, as when allowed to suckle freely. Indeed in certain cases, calf ailments are traceable to the high fat percentage and excessive richness of the dam's milk.

The notes on calf raising which follow are the result of the practice found most satisfactory at the College Experimental Dairy. The system of calf raising outlined here is based on the possession of a herd of medium to good milkers and is restricted to such of their progeny, essentially the female side, which it is intended shall be used for the replacement or the extension of the existing herd or to such as will find a market at a reasonable figure if sold off.

The larger majority of the calves handled by the dairy are buffalo. The buffalo calf is an easier animal to separate from its mother and to hand-feed and the mother is less influenced by the presence or absence of her calf. They are, however, much more delicate than cow calves, and unless care is taken, the mortality may be as high as 75 per cent. Cow calves separated from their mothers can be raised by hand with a little patience though they take to pail-feeding more slowly. Usually, unless the first calf is separated, the maternal instinct of the mother is so strong as to render complete separation of a later calf almost impossible and any attempt to do so produces an adverse effect on the dam's production. Many of the points recorded here are common to both buffalo and cow calves and the methods recommended for raising buffalo calves are equally applicable to cow calves. Since the introduction of these methods in the college herd there has been no mortality among buffalo calves and only one calf died during the period of about twenty months.

For experimental purposes at the dairy and in order to test principles, all calves are maintained alike, though the male buffalo calf receives a slightly lower diet. The male buffalo calf is however an animal which it is scarcely worth raising on any improved lines unless destined as a possible herd sire. Economically, they are more profitable if dead than when alive, and an enquiry into any Indian *gaolee's* business will show that the death-rate among buffalo males is out of all proportion to natural causes and that their natural delicacy, as they are harder to raise than females, is made the most of.

The Dairy deals in both whole milk and milk products. A fair proportion of the buffalo milk is separated. This separated milk provides the basis of the young stock feeding, the balance being sold off.

The high death-rate among young calves, in particular buffalo calves, arises from one or oftener a combination of the following causes :

(1) Lack of sufficiency, regularity and frequency of feeding.
(2) Lack of cleanliness.
(3) Lack of sufficient exercise.

(4) Absence of care at the time of birth and absence of preventive steps against scour, white scour, worms and bronchial diseases.

After a few remarks on the condition preceding birth the subject of calf raising by hand will be dealt with from these standpoints.

While in Calf.

In the large majority of cases the average buffalo remains dry for from 2-4 months. In only two cases in the writers' experience has this period been less than one month. The length of time for which the buffalo will remain dry is dependent on the breed, on the individual, on the length of time which elapses between calving and covering, and on the quality of the fodder supply. The general average amongst the breeds on the college farm is for Delhis 10½ months in milk, 2 months dry; Surtis about 12 months in milk and 3½-4 months dry; Local (Deccani) about 9-10 months in milk and 4-4½ months dry. Thus the necessity of forcibly drying off so as to permit of 6 weeks' rest is so rare as scarcely to require attention. During the earlier part of this period a good supply of nutritious fodder is all that is essential. If the fodder is of poor quality, as is sometimes the case in the hot weather, a small amount of some cheap concentrated food, for instance undecorticated cotton cake, can be fed. It is a mistaken policy to underfeed a milker during the rest period, more especially if she is a high yielder and if the time of rest between drying off and calving is likely to be short. Rich food is not necessary—only an ample amount of digestible material in the fodder is required. Such concentrated food as may be fed in this period is only to be regarded as making good any defects in this respect in the fodder which the owner is forced to feed. Some 3-5 weeks before calving is due, there should be a small addition given in the form of concentrated. This amount should be increased weekly up to calving time, so that she calves on a rising state of vigour. The length of this period of concentrated food and the amount finally fed in the week previous to parturition are dependent on the length of time the animal has been dry or without direct concentrated food and the probable milk yield of the buffalo

after she has calved. If the animal has been dry for some months this period should begin sooner. If the milk yield expected is high the increments added each week and the mass total in the last week should be greater. The foods available at economic rates in the country are variable and so no very definite recipes can be given. The following, however, will illustrate this principle and be the first step towards a liberal milk supply and a satisfactory calf. First week, give $1\frac{1}{2}$ lb., second week 2 lb., and then one additional pound per week up to the fifth week when the diet will be 5 lb. The concentrated should consist of a mixture of oil-cake with either bran or *chuni* in about equal parts. The period before parturition is an important one—perhaps of more importance from the standpoint of the female's milk yield than from the quality and vigour of the calf, unless the female is particularly badly treated at this period, which unfortunately is too often the case. Generally speaking, the better the feeding of the female, especially if in first calf, without extravagance, the better the chance of a virile calf and a good milk flow; that is, provided the female inherently possesses a good milking tendency.

During and After Calving.

At first sight the care and feeding of the female at this period would appear to have but little direct effect on the calf, specially one which is to be hand-fed. There are, however, one or two points which must be closely attended to or the result to the calf may be fatal. Before parturition is due, say some 3-4 days, the female should be separated from the herd, removed from the common stalls and placed in a calving stall, preferably a loose box. In the writers' opinion a room of galvanized iron, with a removable thatch above the iron roof and having a stone floor, and fitted with a half door for ventilation, is suitable. Such a building is sufficiently cool, is easily cleaned, and can be thoroughly disinfected and is free from ticks. The calving female is made comfortable with litter, which should be removed daily or at any rate cleaned and sunned. During this period the diet should be changed to one of laxative type, foods like cotton seed cake and even to some extent *chuni*,

should be avoided. Probably one of the best diets at this period and for some days after calving is one consisting of half *bajra* and half bran or three parts of the former and four parts of the latter. Oats could no doubt replace *bajra*; but the former is the diet fed by the writers. The amount of this mixture will vary between 4-8 lb. according to the expected milk capacity of the mother. The important points at this stage are a clean spot for calving and a laxative diet to prevent any disturbance in the milk (colostrum) production after calving. One of the commonest sources of loss of calves is navel-ill. This is closely associated with infection from a dirty floor and lack of immediate steps to disinfect and tie up the navel string immediately after separation. A calf dropped in the open rarely suffers from this, and, if a suitable calving shed is not available, probably the next best place to tie up is in the open under shade.

THE FEEDING AND MANAGEMENT OF THE CALF IMMEDIATELY AFTER BIRTH.

The calf should be placed before the mother who will lick it and thus remove most of the mucilaginous matter adhering to it. The calf's mouth and nostrils should be freed of mucilage to permit normal respiration and steps should be taken, as mentioned above, to wash the navel with a 5 per cent. antiseptic lotion and tie it up, using silk thread or gut. If not properly cleaned by its mother the calf may be rubbed down with straw. In some cases the calf may be removed immediately after calving and cleaned down in a separate shed, but there is no direct advantage gained. In about 6-8 hours the female will pass her after-birth and by then the calf will be beginning to attempt to reach the teats. This is a point at which management varies. Some raisers permit the calf to suckle for one or two days, others a week or even longer and others remove the calf entirely. In deciding action certain considerations must be borne in mind. These are (1) the effect of removal on the milk flow of the female, and (2) the effect of non-removal on the aptitude with which the calf will take to hand-feeding later. A certain proportion of she-buffaloes do not appear to be affected by the entire absence of the calf. Others, though not requiring the calf to start

the milk flow, are quieter and more easily handled if their calf is beside them. A few cannot be got to milk unless the calf starts the flow. Usually these are buffaloes which have been permitted in the past to suckle their young. In the case of cows the maternal instinct is greater and a cow which has once been suckled by her calf is difficult to handle in its absence and not infrequently refuses to drop her milk, unless the calf starts the flow. As regards the case of hand-feeding later, there is no doubt that the longer the calves are permitted to suckle, the more difficult it becomes to get them to pail-feed. A buffalo calf, separated from its dam, say a week or 10 days after calving, can be got to pail-feed with little trouble and generally without seriously affecting the milk flow of the dam. A cow calf is extremely difficult to train and, indeed, in some cases, impossible, while the cow, even in her first calf, will probably show a falling off in milk. From these facts the writers believe in the immediate separation of calves, particularly in the case of cow calves. Such separation in the case of the latter is possible only if done at the first calf, before the female has had an opportunity of experiencing the effect. In the case of buffalo it is not so absolutely essential, but, with a view to the greater ease with which the calf takes to the pail, it is probably desirable, unless the udder is caked or out of condition. The mother must of course be thoroughly hand-milked in the absence of the calf. Assuming that early separation is decided on, the calf should get its first lesson in pail-feeding some 6-7 hours after calving. This is done by putting the middle and the fourth finger of the right hand in the calf's mouth. When the fingers are introduced the calf begins to suck, and the hand should then be lowered very gently into a shallow vessel containing between one and two pounds of the colostrum drawn from its mother. In the first efforts the calf draws the milk by sucking on the fingers, but in two or three days it will begin to take up milk from the pail, still assisted by the hand, and within a week will drink direct. During the first 10 or 12 days the calf must get its mother's colostrum. Ordinary milk will not do. During this period it should receive its milk at least 4 times a day. The milk fed immediately after the morning and evening milking needs no special attention.

The milk fed at intervening times must be warmed to about 100-101°F. The vessels in which it is fed must be clean and the milk fed fresh. Neglect of any of the above points will probably lead to stomach troubles. After having its milk, it is advisable to wash the calf's nostrils and mouth with water and wipe them dry.

Calf Feeding.

This section refers to feeding till over, at least, 6-7 months of age. The largest mortality in buffalo calves occurs between the age of 10 days and 4 months. The subject of calf feeding by the aid of separated milk and substitutes is one on which a good deal has been written. The schedule below gives the standard lines on which female buffalo calves and males of possible breeding value are raised at the College dairy. It has worked with complete success for the last two or three years. The variation in the character of the substitutes will be discussed later.

Schedule for Pail-fed Calves.

(All buffalo female calves and males of 2 best milkers.)

I. *Period : length* 45 *days*, 0-1½*m.*—(*a*) First 10 days, mother's colostrum 4-5 times a day.

(*b*) Remainder of time whole milk up to about 5 lb. fed in 4 meals.

II. *Period :* 45 *days*, 1½-3*m.*—Whole milk to give way to skim and linseed gruel substitute.

Beginning with 5 lb. whole milk in 3 feeds, skim milk and gruel replace midday meal and later the other two by a process of gradual dilution, till in about 20 days the diet is 5 lb. skim milk. The linseed starts with a few spoonfuls and is eventually raised to about ½ lb. 3 feeds per day. A small quantity of bran and *chuni* is given during this period.

III. *Period :* 45 *days*, 3-4½*m.*—Continue skim feeding 5-6 lb. with (1) ⅜ lb. linseed as gruel followed by 1 to 1¼ lb. bran and *chuni*, or (2) replace linseed and bran-*chuni* by 1 lb. *juar* meal and 1 lb. bran fed after milk. In this period the midday meal should be skim milk with a little linseed gruel or skim milk with a handful of

juar-bran, the bulk of concentrate being fed morning and evening, 3 feeds per day.

IV. *Period:* 45 *days*, $4\frac{1}{2}$-6*m.*—Replace the linseed gruel or a portion of *juar* by cake. Reduce skim milk and cutting out midday meal till in about 10-15 days the milk ceases and the diet is

(1) $\frac{1}{2}$ lb. bran	$\frac{1}{2}$ lb. cake	$\frac{1}{2}$ lb. *chuni*
or (2) $\frac{1}{2}$ lb. bran	$\frac{1}{2}$ lb. cake	$\frac{1}{2}$ lb. *juar* meal.

2 feeds per day.

V. *Period:* 45 *days*, 6-$7\frac{1}{2}$*m.*—Increase concentrates.

(1) $\frac{2}{3}$ lb. bran	$\frac{2}{3}$ lb. cake	$\frac{2}{3}$ lb. *chuni*
or (2) $\frac{1}{2}$ lb. bran	$\frac{1}{2}$ lb. cake	1 lb. *juar* meal.

2 feeds per day.

VI. *Period:* 135 days, $7\frac{1}{2}$-12*m.*—Reduce concentrates till by 10 months or so, 1 lb. is being fed of either of above mixtures, 2 feeds passing to one.

Fine fodder should be given in the second period and by its close the calf should be consuming a fairly appreciable amount. It should be allowed access to what it requires. The fodder given should be of good quality. It should also be as succulent as possible. If, however, it is unused to succulent material its introduction should be gradual, though eventually it can form a large part of the fodder diet. At the College farm succulent food is met between mid-July and mid-September by grass, mid-September to mid-December by *sorghums*, from mid-December to mid-April by berseem and the balance of the year by silage. Very young calves, if born in the silage period, depend on a small quantity of guinea grass in the early stages of fodder feeding. The milk or separated milk fed should approximate in temperature to about 100°F. Morning and evening feeds immediately after separation do not require special attention, as, at the dairy, separation of buffalo milk for butter or *ghi* purposes follows immediately on milking and the fall in temperature is inappreciable. The midday feed requires warming to about 100-101°F. The linseed is weighed out according to the needs of the stock and made into a gruel, using 1 part of linseed to 6 of water. A quantity of this gruel proportional

to the weight of linseed due to a calf, is then mixed with the skim milk. An important point is that the vessels in which the milk is fed must be kept thoroughly clean and should be scalded as thoroughly as if for human use. Calf illness is not infrequently traceable to lack of care in this respect. The grain feed is weighed out on the same lines, moistened some time in advance and fed by measure after the milk. At feeding time the calves are tied separately; each then receives its portion in an iron bowl. Tying at feeding permits the slower eater to complete without being worried or robbed, prevents calves sucking each other and ensures that each gets its proper share. Attention should be given to the dung, generally passed after feeding, as this affords a fairly ready index of health and the suitability of the diet. It is a mistake to imagine because skim milk is being fed in place of whole milk that a larger bulk of milk is necessary for support. The amounts of milk fed in the schedule are sufficient, and attempts to markedly increase these have generally resulted in diarrhœa.

With regard to the nature of the substitute the writers are of the opinion that up to about the middle of the second period linseed gruel forms one of the best substitutes. After that date considerable variation is possible.

The following experimental feeding illustrates this and is the cause of the duplicate feeds in the schedule. Frequently it may be found to be more economical to use a grain diet. The calves of both groups were alike in age and averaged about 3 months, and up to the date of starting the experiment, both had been raised on separated milk and linseed as outlined.

The diets for groups A and B were as follows:—

	Group A	Group B.
1st period 45 days.	5 lb skim milk	5 lb. skim milk
	2/3 lb. linseed gruel	1 lb *juar* meal (fed after milk)
	½ lb. bran (fed after milk)	½ lb. bran (fed after milk)
	½ lb. *chuni* (fed after milk)	
2nd period 45 days.	½ lb. *chuni*	½ lb. *juar* meal
	½ lb. bran	½ lb. bran
	½ lb. *tilli* cake	½ lb. *tilli* cake
3rd period 30 days	2/3 lb. *chuni*	½ lb. *juar* meal
	2/3 lb. bran	½ lb. bran
	2/3 lb. cake.	½ lb. cake.

Thus in group A in the first period there was higher proportion of oil and proteid, in group B a higher proportion of carbohydrate. In the subsequent periods A differed from B in having a higher proportion of proteid. All the animals maintained a good condition and the development of the parts of the body was alike. In the first period, animals in B group in the beginning showed some slight tendency to scour and they were at the end perhaps a little softer on handling.

The following are the progressive average gains per head of each group :

	End of 30 days	End of 60 days	End of 90 days	End of 120 days
Group A	18 lb.	38 lb.	68 lb.	92·6 lb.
Group B	31 lb.	59·6 lb.	91 lb.	119 lb.

Group B thus made an average gain per head of 26·4 lb. in 4 months.

The amount fed	A per head	B per head
Skim milk	195 lb.	195 lb.
Linseed	25 lb.	—
Juar-meal	—	93 lb.
Chuni	95 lb.	—
Bran	48 lb.	60 lb.
Cake	49 lb.	49 lb.
Cost Rs.	13-10	12-10
Price per lb. of increase live weight. ...	2·35 annas	1·70 annas.

Feed B thus gave a greater increase and cost 0·65 anna less per lb. As there are considerable divergences in the characters of the two diets a fairly wide margin of food stuffs is apparently possible. The general results bear out similar experiments on cow calves in America.

Housing and Exercise.

Young calves do not require very elaborate housing, at any rate in the Central Provinces. The general calf shed is a galvanized iron building covered with a thatch, protected towards the south-west and north and open towards the east. In the writers' opinion

both the iron and the thatch are important. Iron prevents the existence of harbours for ticks and other parasites and an external thatch makes such a building habitable in the hot weather. The floor of the shed is dry earth and raised about 6″-7″ above the general ground level. It is divided into three compartments and each compartment has a fenced run to the east of the shed, about four times the width of the shed in length. Possibly four sections might be advisable, but are not essential.

In the coldest and wettest parts of the year, the youngest calves are generally housed at night in a large loose box, as, if unprotected, they are subject to broncho pneumonia. In the general shed the chief points to pay attention to are (1) protection against rain and excessive heat, (2) freedom of movement at will, (3) a grading of the calves to each section according to age and size, and (4) cleanliness. In addition to the movement possible in the small paddock, calves should be allowed to go out daily in a neighbouring field in the general farmyard. Ample, though not excessive, exercise is an important item in keeping them fit.

Watering, Salt and Lime.

During the first month or so the calf shows no demand for water —the water in the milk being sufficient; after this—in particular when they have begun to take up fodder—the need increases. There should be ready access to a clean water supply, preferably in a water trough in the calf pens. If this is not fitted in the calf pens, they should be taken to the water supply at least twice a day in the cold weather and four times a day in the hot. The fact that a calf needs water in addition to what it gets as milk is too often overlooked in rearing calves by hand and causes the calf to gorge the milk with bad effects.

Salt is an essential. It should be supplied in small quantity with the concentrated food. At the same time it is not a bad plan to have a block of rock salt hung in each pen or shed. It

strengthens the appetite and stimulates digestion, a factor of some importance in keeping condition. In the pen in which the calves under three months are kept it is advisable, in addition to rock salt, to hang up one or two blocks of chalk. The young calves will lick these readily. The effect is two-fold—prevention of scour and a prevention of the habit of licking the floors and ground, which is not infrequently the cause of stomach trouble and intestinal worms. The necessity for lime appears to decrease as soon as the diet begins to include an appreciable amount of dry food.

Other Points of Care.

Buffalo calves, generally, are exposed to attacks of hoose, broncho pneumonia, scour, white scour, tympany, intestinal worms, mange and lice. If care is taken on the lines indicated in this article, the possibility of these is very largely reduced. In addition, however, two points might be mentioned which have been found of considerable value in checking mortality. The first is an inspection of the dung and prompt action if anything abnormal is noticed. The second is the administration of preventive doses, at intervals, of raw linseed oil and turpentine.

The following is the schedule of this measure as adopted at the dairy.

Age	Quantity of linseed oil	Quantity of turpentine	
1st month	1 oz.	⅛ oz.	To be administered once every fortnight.
2nd, 3rd and 4th months.	1½—2oz.	¼ oz.	
5th and 6th months ...	2 —2½oz.	½ oz.	
7th-12th ,, ...	3 oz.	1 oz.	Administered once a month.

The usual methods of dealing with ringworm, mange and lice need no repetition.

Calves over one year—development of the buffalo heifer. Practically speaking from about 10 months old and onwards calves require but little special attention as long as they receive

ample digestible fodder, free access to water and exercise. Though inferior or inadequate nourishment should be carefully avoided, the effect of a temporary falling off of this at this time is not so disastrous as in the early stages. Concentrated foods are not essential except under inferior-quality-of-fodder conditions. A certain amount of grain during this period will result in a bigger growth and earlier maturity. A regular grain ration at this period is however too expensive to be economical. Grazing is the cheapest and, if ample, is the best way of raising the calves. At the College dairy, on account of the absence of grazing of any real value, the young stock are raised on fodder. The only advantage of feeding on fodder lies in the fact that the quantity and quality are more regular throughout the year. Most Indian grazing is defective in these respects. If young stock are to be raised on such grass areas it is necessary to reserve some of the area for hay. Cut and store this in October and feed a liberal hay ration between February and the end of July. During this period about a couple of pounds of concentrated is desirable, in order to keep the animals in a thrifty growing condition. The amount of this concentrated will naturally depend on the quality of the roughage. In addition to the hay of the poor local grasses round Nagpur, 2 lb. of cotton seed or 3 lb. of undecorticated cotton cake are found to just maintain heifers in a growing condition at this period. At the College farm, by reason of the inclusion of berseem up to the beginning of April and the better quality of the fodder, concentrates are fed only for about three months, only a pound usually being given. Succulence in the fodder fed has a marked effect in the rate of development. In one case in which the same concentrated diets were used (1) with the dry poor hay available in the hot weather and (2) later with grass in the months of August and September, the average increase in live weight per head over the same time was practically double in the second period. The use of silage as part of the roughage fed in the hot weather can be recommended. A buffalo heifer which has received treatment along these lines will probably be found to weigh about 900—1,000 lb. when 3½ years old before giving birth to her first calf.

Cost of System per head.

		Rs.	A.	P.
1st year	165 lb. of whole milk at 12 lb. per rupee	13	12	0
	350 lb. of separated milk at 30 lb. per rupee	11	10	0
	60 lb. of linseed at 15 lb. per rupee	4	0	0
	187 lb. of *tilli* cake at 40 lb. per rupee	4	11	0
	157 lb. of bran and *chuni* at 22 lb. per rupee	7	2	0
	2,430 lb. of fodder at 200 lb. per rupee	12	2	0
	Labour per calf (estimating 20)	3	3	0
	Shed rental	0	8	0
	Cost for 1st year	57	0	0
2nd year	120 lb. concentrated foods at 40 lb. per rupee	3	0	0
	4,440 lb. of fodder at 200 lb. per rupee	22	3	0
	Labour and rental	3	8	0
	Cost for 2nd year	28	11	0
3rd year	180 lb. concentrated foods at 40 lb. per rupee	4	8	0
	5,750 lb. of fodder at 200 lb. per rupee	29	0	0
	Labour and rental	3	0	0
	Cost for 3rd year	36	8	0
	Total cost per head	122	3	0

If the stock in the second and third years are raised on grazing areas where hay would be cheap the cost per head would not exceed Rs. 95. It might even be possible to reduce the cost slightly further by a reduction of the period on whole milk.

A ttheir first calving, any of the young Delhi and Surti buffaloes on the College farm raised on the above lines are worth Rs. 125-130 and more, if we take into consideration the cost of carriage from the place of purchase.

AMERICAN COTTON AND AMERICAN COTTON SALES IN THE PUNJAB.

BY

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COTTON sales have become a feature in the successful introduction of American cotton by the Punjab Agricultural Department. It may therefore be of interest to give some account of them. In a previous article[1] in this journal the writer gave a brief account of the history of the introduction of American cotton in the Punjab Colonies. It was then pointed out that the first sale was started in 1905-6, only three years after the first trial of American cotton. From 1908 to 1913 two sales were held annually, *viz.*, one at Sargodha in the Jhelum Colony and one at Lyallpur on the Lower Chenab. In these early sales the object was merely to help zemindars to get a good price for their superior produce. A small quantity of new seed was imported by the Department yearly from Dharwar in the south of Bombay. Comparatively small quantities of cotton (*kapas*) were brought to these sales, a few hundred maunds as a rule. Premiums up to Re. 1-8 and more a maund were obtained but the effect was to fix the price of American cotton for the whole tract. In 1911 and 1912 factory owners began to pay some premiums independently of the sales. In 1913 the Department was in a position to give out a special variety selected by the Economic Botanist and handed over for further trials to the writer. From 1913 onwards these sales acquired a new importance as it

[1] *The Agri. Journal of India*, vol. X, part IV, pp. 343—48.

became necessary for the Department to get back the seed for further distribution. The area sown under this special variety No. 4 F in 1913 was only 100 acres, in 1914 it was 3,000 acres and in 1915 in spite of the effect of the war on cotton sowings the area under 4 F rose to 9,000 acres. In the present season it is estimated that over 30,000 acres will be sown with this variety. In the article previously referred to the writer ventured to prophesy that in spite of the disastrous effect of the war on cotton prices the area under American in the Punjab would not decrease. This was amply fulfilled and something like 65,000 acres was sown with American of all kinds last year. The season, though distinctly bad, was more favourable for American than *desi*. The prices obtained at the sales this year were so good that at a moderate estimate there should be about 120,000 acres sown with American of all kinds in 1916. The above was written during the Meeting of the Board of Agriculture at Pusa (February 1916) and now two months later when cotton sowings have started the whole of the seed with the Department amounting to 2,000 maunds in Lyallpur and Montgomery and about 600 maunds at Sargodha has been already disposed of. Much more could have been sold. Numbers of zemindars, who waited till sowing time before buying seed, have had to be refused daily since April 1st. No better evidence than this is necessary of the willingness of the cultivator to adopt a new thing if it pays him. It is estimated that over 500 maunds seed was retained by last year's growers and hence well over 3,000 maunds of seed has been distributed. The seed rate here is 4 seers per acre and therefore 3,000 maunds means 30,000 acres. The Department now control directly therefore at least $\frac{1}{4}$th of the area. This year's sales were held at five centres in the Lyallpur circle (as compared to two last year) and two in the Jhelum Colony in the circle of the Deputy Director of Gurdaspur (as compared to one last year). Altogether about 8,000 maunds of *kapas* (seed cotton) was sold at these sales. Of this about 4,500 maunds was first class and was ginned under the Department's supervision for the purpose of getting the seed for distribution. This year some changes were introduced in the conditions of the sales which may have far reaching results. The most important

of these relates to classification of all the cotton by the Department and the leaving of all arbitration in its hands. These conditions were operated with great smoothness throughout and to the satisfaction of sellers and buyers alike.

Another feature of this year's sales was the fact that Messrs. Tata and Sons sent up a representative at the writer's request and it was he who bought the greater part of the cotton either directly or indirectly at the sales.

Very good prices were realized ; in one sale the price paid was Rs. 3-13 more than for *desi* cotton on the same day. The average price per maund of *kapas* in Lyallpur was Rs. 10-12, the price of *desi* being Rs. 7-8. The premium was therefore over Rs. 3. No doubt the war partly accounts for the high price, as imports from America are restricted owing to high freights. Last year, however, when freight was not such a burning question the premium was Rs. 2-13 a maund. In the past season American cotton yielded well per acre as compared to *desi*, though both suffered in yield owing to the excessive drought. The flowers all appear together in the common *desi* cotton grown here and the strain on the plant is enormous at that period. In American, on the other hand, the flowering is much more gradual, and hence the strain at any particular time is less. It was a common sight to see fields of *desi* cotton in July and August strewn with fallen flowers. Zemindars here boldly say American cotton yielded twice as much as *desi*. The extra profit, for 65,000 acres even assuming the American yielded only 1 maund more per acre is over 6½ lakhs without taking into account any premium. The total extra profit to the grower last year may therefore be estimated as 12 lakhs assuming only one-eighth premium per maund.

In the present year with 120,000 acres and assuming a premium of Rs. 2 a maund and an equal yield with *desi*, *i.e.*, an average of 6 maunds per acre the extra profit will be 6 × 2 × 120,000 equal to 14·4 lakhs. No one who knows the facts can doubt the moderation of the above estimate.

It is very satisfactory to note that this cotton is doing very well in the new Canal Colony—The Lower Bari Doab. In one

estate where 250 acres were under this cotton a total yield of close on 2,500 maunds was obtained or nearly 10 maunds per acre. It is estimated that the area under American in this colony this year will be at least 15,000 acres, of which over 10,000 will be pure 4 F.

In Lyallpur one grower this year has 2,000 acres under 4 F cotton. It may be pointed out here that not only is the seed being taken by the people from the Department but a very large and increasing number of growers are beginning to pay serious attention to improved cultivation, especially sowing in lines, and interculture—a practice so far quite unknown in the Punjab.

It may be of interest to speculate as to the possible final area of American that can be grown. The average area under cotton in the following districts where American has been successfully introduced is as follows :—

	District	Total area irrigated, 1914-15	Total area under cotton, average of 5 years	Estimated area under American cotton in 1916
		Acres	Acres	Acres
Lower Jhelum Canal ..	Shahpur ...	892,684	108,439	20,000
Lower Chenab Canal ...	Lyallpur ...	1,600,000	158,358	40,000
	Gujranwala ...	921,411	74,000	7,000
	Jhang ...	640,594	49,207	35,000
Lower Bari Doab Canal ...	Montgomery ..	670,428	20,000 (acres in 1915)	15,000
	Other districts...	......	......	3,000
	Total ...	4,725,117	410,004	120,000

As the area under cotton in the colonies is generally 10 per cent. of cultivated area, we may expect a big increase in Montgomery. The total area under cotton in the colonies will be roughly 440,000 acres, of which we may expect ultimately 300,000 acres to be under American. A certain proportion of *desi* cotton will undoubtedly continue to be grown especially in very light soils and near the tails of the canals where water conditions are precarious and late sowings are common. In such tracts probably the **Red Sanguineum** *desi* variety or perhaps a *Neglectum* type will be safer to grow.

The amount of American cotton in other districts outside the above is probably not as much as 5,000 acres, though it is being tried widely nowadays practically all over the province.

The marketing of American cotton still leaves much to be desired. The trade is mostly in the hands of Indian ginning factory owners at present, the European firms having done a comparatively small business up to date. Bombay is the chief buyer. What is curious about the business is the almost universal mixing that goes on in the ginning factories. The usual grade sent to Bombay contains from 10 to 30 per cent. of *desi* cotton. Some of the factory owners are very frank over this mixing, and the writer has often seen American cotton with 20 to 30 per cent. of *desi* being added to it before ginning, especially in the Jhang District. One reason for this is that *desi* cotton has a better colour than American and no doubt the mixture looks whiter than pure American. One would expect spinners would find the defect. Individual spinners in Bombay stoutly deny that they want such mixtures, yet that is what they mostly get and pay for.

It might be pointed out that the ginning outturn of all cottons was low last year, and thus there was more than the usual percentage of short fibre. This fact no doubt facilitated mixing with *desi*.

The dangers for the seed from this and other causes will probably make it necessary to brand 4 F bales in future. The point is receiving careful attention. It is satisfactory to note that this year as well as last year a good deal of cotton was sent pure both to Bombay and Nagpur.

The widespread growing of American cotton is brought home to any one walking in any part of the above tract comprising the Lower Jhelum, Lower Chenab, and Lower Bari Doab Canals. There is scarcely a village without a field or two of American, and in some places practically no *desi* cotton can be seen for miles. As an instance of the indirect effect of the cotton sales the case of certain large growers near Lyallpur may be mentioned. Up to the day of our first sale the best price offered to these zemindars was Rs. 10 per maund, whereas the day after the sale they were offered Rs. 11, and some actually sold privately at Rs. 11-4 a maund of *kapas*.

IMPROVED SUGARCANE IN THE UNITED PROVINCES.

BY

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THE Sugarcane Research Station at Shahjahanpur was opened in 1913, and the work of selecting improved varieties of sugarcane was seriously taken in hand in the United Provinces. Results were obtained in a very short time.

The Research Station is fortunate in being situated near a large central factory at Rosa and since results have been available, the staff of the factory have given invaluable assistance in the distribution of improved canes and in testing the results on a factory scale.

The improved cane illustrated (Plate VII) was grown in shallow trenches, 18 inches wide and 6 inches deep with a space of 18 inches between each trench, that is, the cane rows were 3 feet apart. It was manured with castor-cake meal at the rate of 30-40 maunds per acre and irrigated by means of a pumping installation from the neighbouring river.

Before the rains it was earthed up, and it is due to this that the crop remained standing during the abnormally heavy rains and winds of the monsoon of 1915.

The importance of the latter operation cannot be over-estimated. Heavy crops of improved canes grown on the light soils of Rohilkhand that are not earthed up almost invariably fall down during the heavy rains and high winds that prevail during the monsoon in the sub-montane tracts. The quantity and particularly the quality of the *rab* and *gur* are badly affected. In fact it is

impossible to obtain the light coloured *danedar rab* and *gur*, so much prized in the bazaar, from fallen cane.

It is impossible to give an accurate figure of the cost of growing cane, as this depends on many factors that are affected by local conditions, such as cost of labour, price of oil-cake meal and cost of irrigation, etc. The trenching described above costs in the Shahjahanpur District, where labour is not particularly cheap, Rs. 15 per acre and, considering the fact that a crop of improved canes such as that illustrated will yield *gur* and *rab* worth Rs. 350 to Rs. 450 per acre, this additional outlay cannot be called excessive.

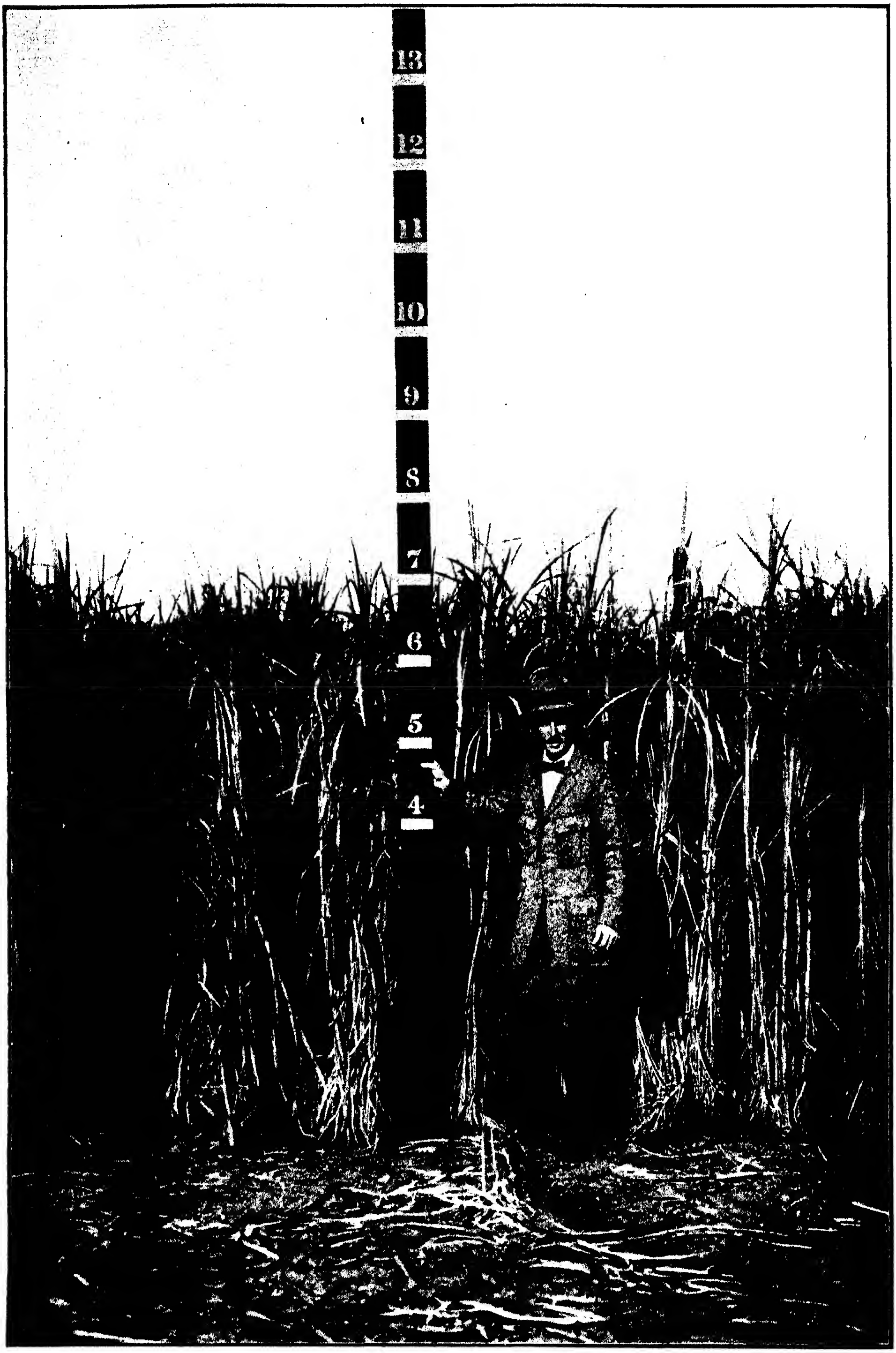
The yield of cane in the field illustrated was just over 600 maunds per acre trimmed cane, containing 11·78 sucrose per 100 cane. This was in a year when the outturn of sugar was very low, the *desi* varieties yielding 8-9 sucrose per 100 cane in this district.

The milling properties of the improved cane were tested on a factory scale in a nine roller mill capable of crushing over 500 maunds per hour. Sixty tons of cane were crushed in each test. At the author's request the milling was arranged for without the addition of maceration water in order that the results might be compared with those obtained at the Research Station on a smaller scale. The following results were obtained without maceration at the factory :—

Juice expressed per 100 cane	70·60
Sucrose per 100 juice	14·35
Purity of juice	82·00
Glucose per 100 juice	1·41
Sucrose per 100 bagasse	5·60
Sucrose per 100 cane	11·78
Mill extraction	86·00

These figures are of interest as being the first published of the results that can be obtained on a factory scale with improved canes in these provinces. As already stated, maceration was not employed and the mill extraction (86) would be increased to an appreciable extent by the use of the usual 10-15 per cent. added maceration water. These figures confirm numerous tests that have been made with this cane on a smaller scale at the Research Station with small bullock mills and small power mills.

A medium thick cane (J. 33) selected at the Sugarcane Research Station, Shahjahanpur, for distribution in the Rohilkhand Division of the United Provinces. The photograph was taken in a field grown at the Rosa Factory under the supervision of Mr. H. D. Lang.



Chunni, a local cane of the Shahjahanpur District. The photograph was taken in a neighbouring field grown at the same factory.

Another improved variety of cane, Ashy Mauritius, was grown on a large scale at the factory in 1915. It is a thick variety of the *pounda* type and can only be grown under conditions of intensive cultivation. It has been under experiment in these provinces for 10 years and has given consistently high returns both as regards yield of sugar per acre and quality of *rab* and *gur*. It requires more care in cultivation than J. 33 but it is an excellent cane, well worth a trial where proper care and attention can be given to it. It is one of the very few canes of this type that fully mature during the short growing period of Upper India.

At the Research Station it has given, through a series of years, 100-120 maunds of *rab* per acre.

The milling results obtained in a nine roller mill at Rosa in 1915 without the use of maceration water were as follows:—

Juice expressed per 100 cane	70·90
Sucrose per 100 juice	16·34
Purity of juice	88·30
Glucose per 100 juice	0·57
Sucrose per 100 bagasse	7·40
Sucrose per 100 cane	13·74
Mill extraction	84·30

The author is indebted to Mr. E. Simmons for kindly placing at his disposal for publication the two photographs illustrating this article. They were taken at Messrs. Carew & Co.'s Factory, Rosa, in the Shahjahanpur district in the United Provinces.

PHOTOGRAPHIC ILLUSTRATION.

BY

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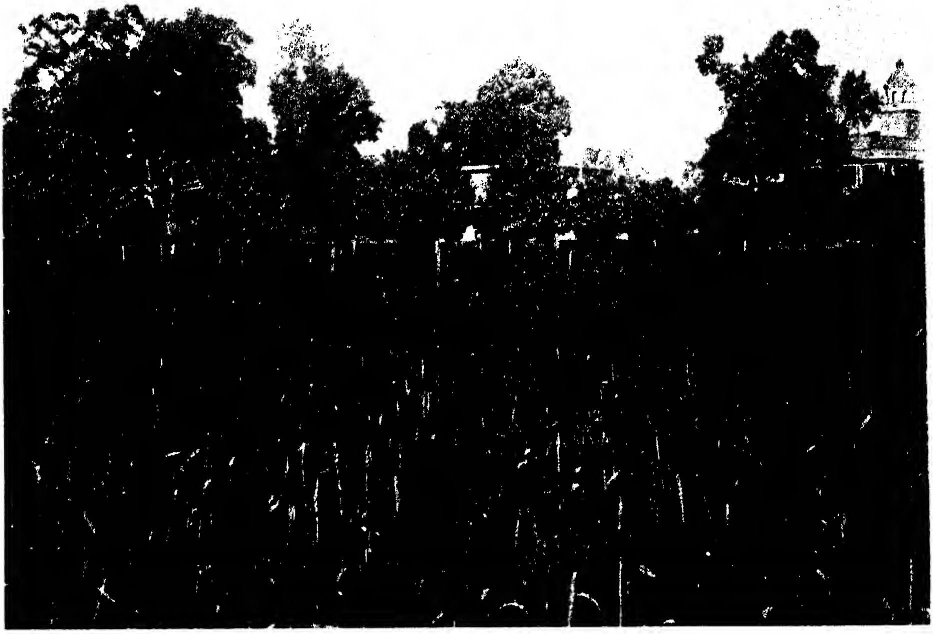
Imperial Agricultural Bacteriologist.

A LARGE majority of the photographs taken to illustrate scientific writings are reproduced as half-tones, and in order to be successful as illustrations must bear certain characters which are necessary for success with this process although they may not be essential for ordinary pictorial representation as photographic prints. Half-tone reproduction of necessity reduces contrast and in many cases eliminates fine detail, so that it is necessary to aim at a negative in which contrast will be exaggerated, and to produce one on such a scale as will allow the smallest detail required to be shown in the final illustration, to appear sufficiently marked to avoid elimination. This is especially the case with such subjects as include written characters or figures, which in many instances become entirely illegible in reproduction through reduction in scale. It may be well here to point out the advisability of including, in many subjects, a scale of inches or feet, or some object of standard size such as a watch, or for outdoor subjects a figure, without which many photographs both in text-books and scientific memoirs lose illustrative value. For half-tone reproduction what is called a " hard " negative is preferable to one showing fine gradations of tone merging into one another; hardness in this sense means a sharper definition of the edges of the high lights and a greater obvious contrast between the high lights and shadows. Such hardness is entirely wrong in pictorial photography, where the object aimed at is the rendition of atmosphere by means of a fine scale of gradation between the

WHEAT PLOTS.



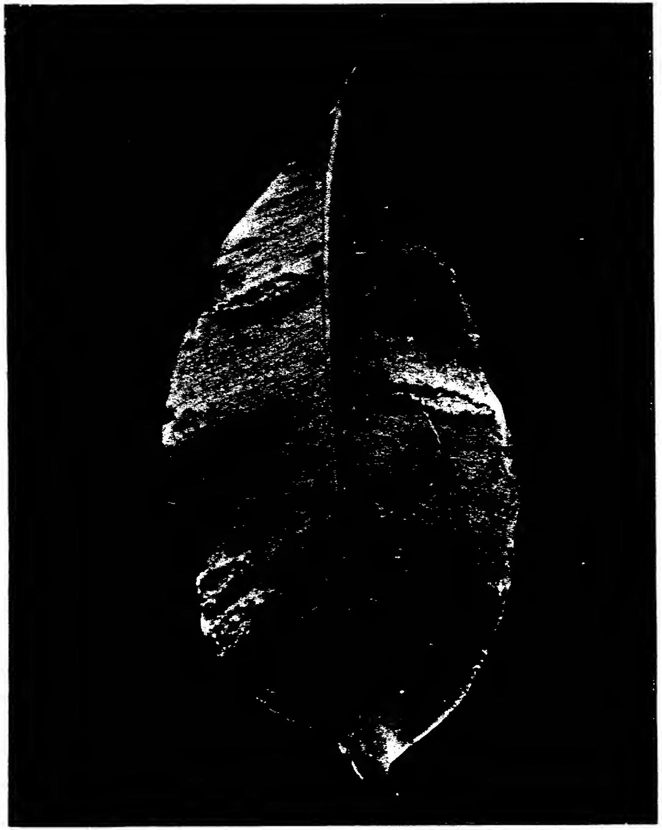
(a) TAKEN AT MIDDAY JANUARY 25TH.

(b) TAKEN AT 4 P. M.

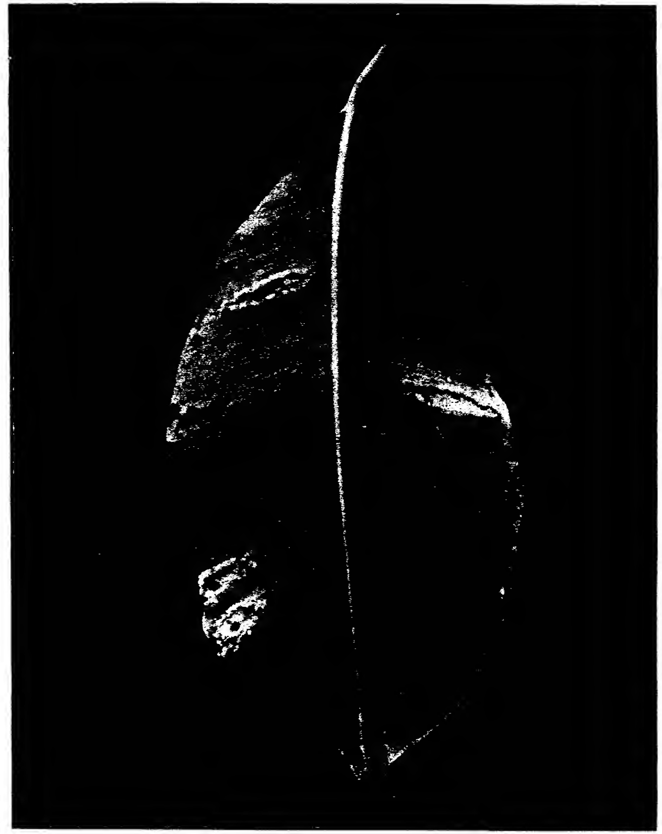
To show advantage of using evening light.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1916.

INSECT GALLS ON LEAF.



(a) ILFORD ORDINARY PLATE.



(b) WRATTEN M PLATE AND YELLOW SCREEN. (WRATTEN K_3).

To show superiority of Ordinary over Orthochromatic Plate for subjects depending for proper delineation upon shadow contrast rather than colour differences.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1916.

various tones of the picture, this result being attained largely by adapting the style of the negative to the process of printing or *vice versa;* when P. O. P., Bromide, Carbon or Collotype are admissible an entirely different class of negative can be aimed at, but for half-tone reproduction of such subjects as generally come into scientific papers, a soft, evenly gradated negative is not desirable, but rather a hard, vigorous one. It must also be remembered that owing to the "grained" character of the half-tone block, no great range of tone is admissible in pictures to be reproduced by this process, so that in taking out-of-door subjects due allowance must be made for the loss of vigour resulting from the compressed scale of tones. It is unfortunate that in India other more truthful processes such as photogravure and collotype become so expensive, on account of the climate, that they cannot be made use of in our publications so long as considerations of convenience necessitate the use of illustrations produced in this country. It is also to be remembered that the limitations of the half-tone process in many cases render it advisable to make use of line block reproduction in preference thereto. The class of negative suitable for half-tone reproduction can be got in various ways, the chief points to attend to being (1) lighting, (2) exposure and development, (3) class of plate and use of light filters.

Lighting. This is not always under control, but it is generally possible to select a time of day when the subject will be lighted from the side rather than from directly overhead; *i.e.*, the morning or evening rather than midday which in most cases in outdoor subjects will give better contrast. In nearly every case a study of this point will reveal the best time of day for obtaining a vigorous negative, and one which will show those characteristic features of the subject which it is desired to bring into prominence (Plate IX, fig. (*b*), Wheat Plots).

In many cases, such as that illustrated in Plate X (Insect Galls on Leaf) side lighting in place of diffuse or direct illumination is essential for successful representation of the object.

Exposure. This is of paramount importance, as is of course generally recognized, and it is only referred to here on account of the

apparently very general failure to avoid serious errors in this respect; the commonest fault, in the writer's experience, tends to be over-exposure combined with the natural corollary of under-development; this is not so bad a fault as under-exposure and over-development (although the results are very similar) since the photographer is generally unable to stop development before so much of the picture has appeared as will allow of considerable improvement by intensification at the hands of the reproducer. The writer has noticed that a considerable number of amateur photographers in India have so little confidence in their power of correctly estimating exposure that they habitually commence development with only half the quantity of accelerator recommended by the makers of the plate in their carefully calculated developer, and as most of the plates are over-exposed, development is finished with this half strength solution. The resulting negatives are in many cases regarded as good ones by their authors, but they are not of such good quality as would have been attained either by a shorter exposure and development with full strength developer, or with the same over-exposure and development with full strength developer restrained by pot. bromide. It is therefore generally better to give a full exposure, in case of doubt as to how much should be given, and use full strength developer with bromide rather than the method referred to above. The resulting negative is generally hard and the contrasts are sometimes somewhat too violent for the best pictorial effect in ordinary printing, but for half-tone reproduction this is a fault on the right side, provided the hardness is due to slow development and not to under-exposure. It may not be out of place here to draw attention to a point which is liable to escape the notice of those who may have had a considerable amount of successful experience with such open subjects as more generally attract the amateur photographer; when photographing a single object such as a plant in a pot, due allowance is sometimes not made for the very great increase in exposure required by the heaviness of the shadows in such a near object as compared with that of such shadows when a similar plant forms only a small part of the picture in an outdoor subject. For the same reason it is all the more necessary to make

BUTTERFLIES.

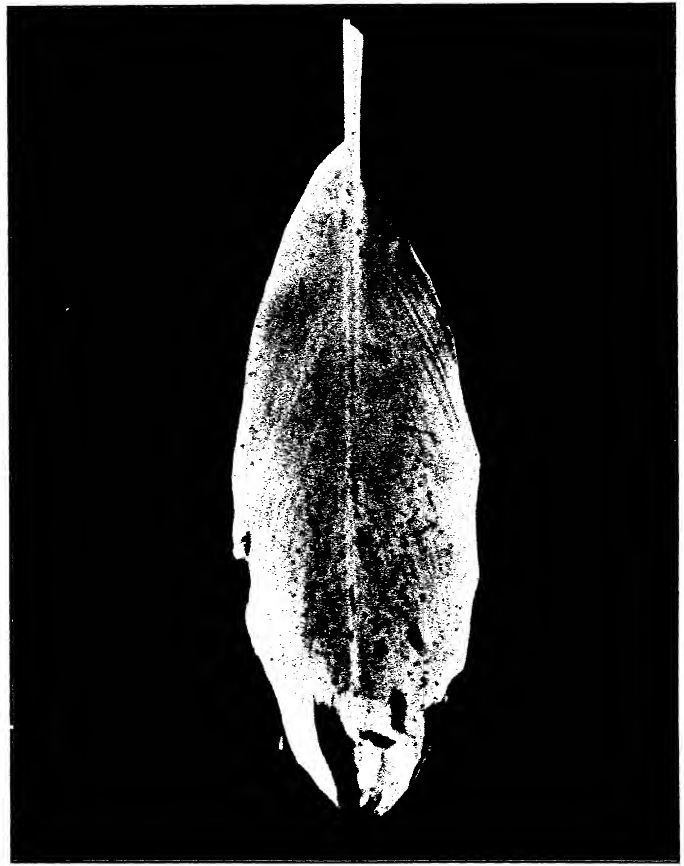
(a) ILFORD ORDINARY.

(b) WRATTEN M PLATE AND YELLOW SCREEN. WRATTEN K 3.

To show necessity for use of Orthochromatic plates for such coloured subjects. Upper butterfly has orange-yellow underwing; lower butterfly is sulphur coloured.

FUNGUS SPOT ON LEAF.

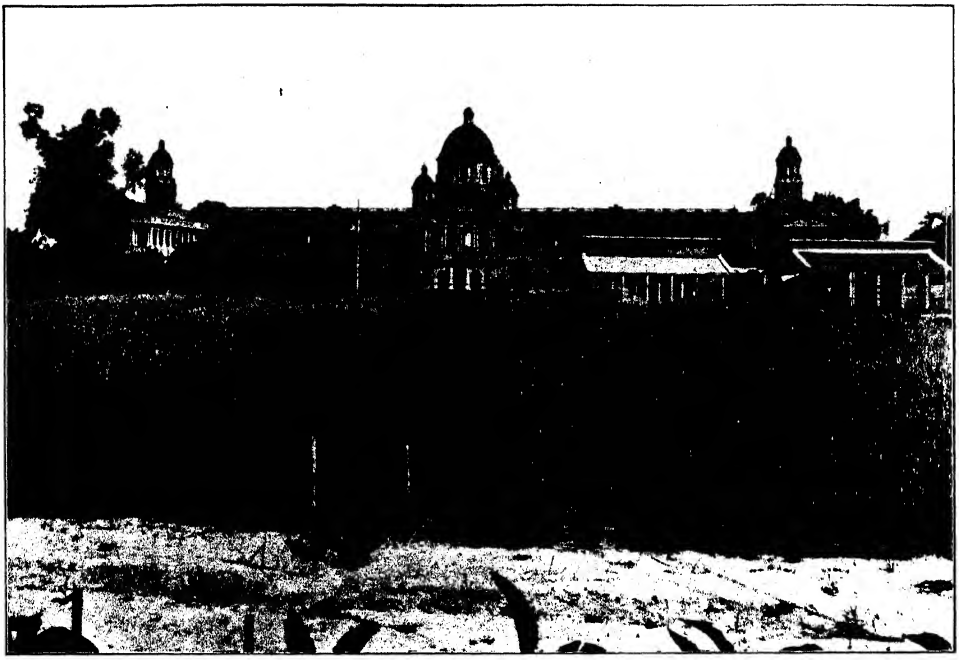
(a) ILFORD ORDINARY.



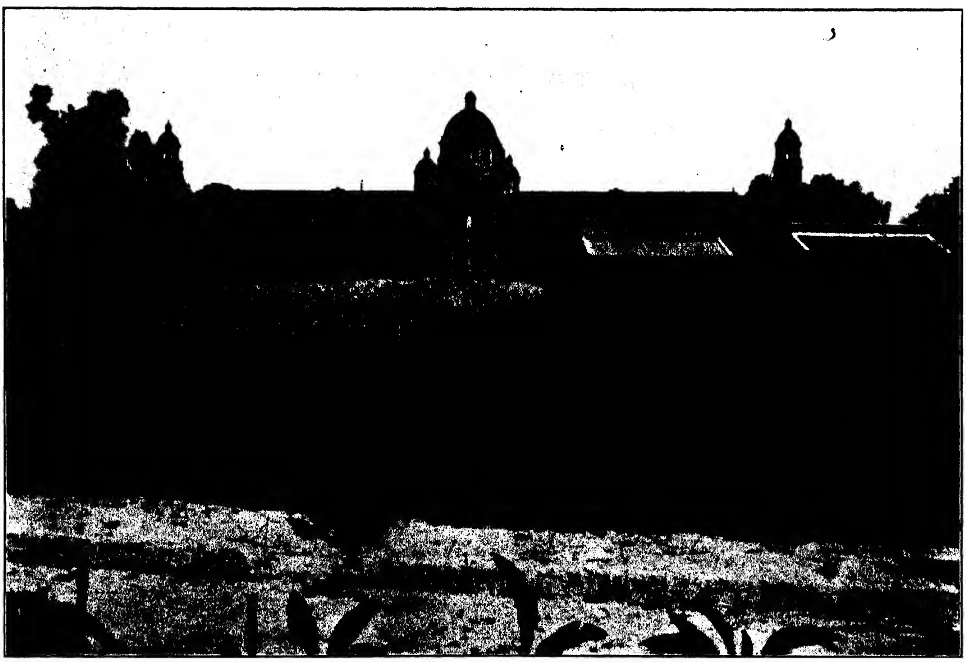
(b) WRATTEN M PLATE AND YELLOW SCREEN. (WRATTEN K_3).

Colour correction to show black on yellow.

OAT PLOTS.



(a) ILFORD ORDINARY.



(b) WRATTEN M PLATE AND RED SCREEN. (WRATTEN A).

Over correction to show yellow on green.

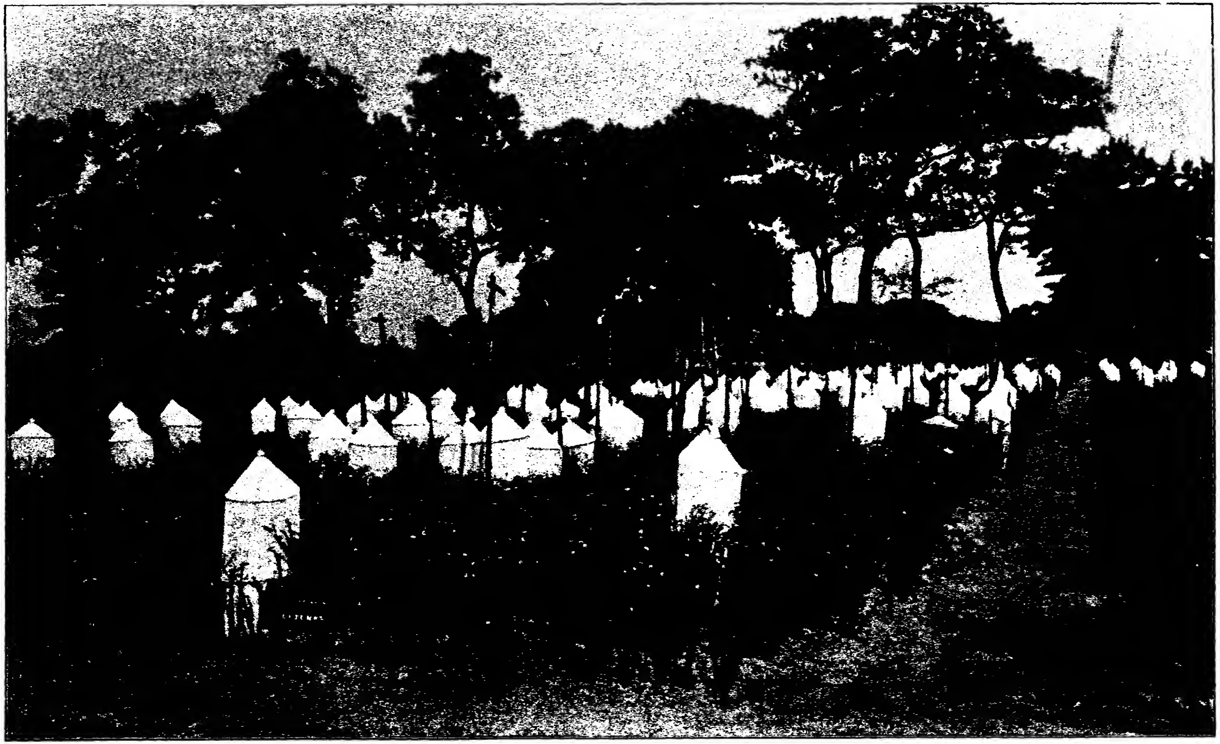
such allowance when photographing an object (such as a single leaf) so as to reproduce it very nearly life size.

Class of plate. This implies various alternatives, such as slow or rapid, ordinary or orthochromatic, backed or unbacked plates. Films need not be considered, as they are not only expensive but are extremely unreliable in this climate. Generally speaking, slow plates are to be preferred to rapid ones, not only on account of their comparative ease of development and the brilliant negatives which can readily be got from them, but because of the very great latitude of exposure which they permit. This is an inherent quality resulting from their method of manufacture, but is also partly due to the fact that, owing to the comparatively good light in which they can be developed, control of this operation is simplified. Provided a slow plate is not under-exposed a good negative can be obtained from it, under almost any other conditions of exposure, even up to ten or more times that necessary to produce the best result, and as most agricultural subjects admit of time exposures of considerable duration, the use of slow plates may be recommended in preference to fast ones whenever possible. Even in photographing out-of-door subjects which may be affected by wind movement, it may be pointed out that, by stopping down and giving a sufficiently long exposure, a moving branch or crop will, except when the wind movement is considerable, appear sharp in the resulting negative. Furthermore it is very generally true that slow plates are not so liable to deteriorate in the Indian climate as are faster and especially orthochromatic ones, nor do they exhibit so much tendency to suffer from chemical fog due to high temperature of the developer as is shown by the latter class of plate. It is perhaps unnecessary to speak of the greater liability to light fogging which accompanies the use of extra rapid plates, although it may be mentioned as perhaps not being generally known that this may take place through some parts of the materials of the camera and dark slides in bright sunlight, especially the hinged part of the shutter of the dark slide and the leaves of between-lens shutters, which allow a considerable amount of red light to pass through them when made of vulcanite, as they frequently are. It is also worthy of note that slow plates give negatives of much

finer grain than do rapid ones, and this is an important distinction when lantern slides or enlargements are to be made from them. A good many subjects, however, require the use of fast plates in order to enable shutter exposures to be made, and in this connection it might be well to point out the advantages of the small hand camera as being suitable for many subjects which do not demand representation of fine detail but are merely intended to help a written description by pictorial illustration. Many such subjects (*see* Frontispiece) will be found photographically reproduced in the publications of this and other Agricultural Departments, and it may be said that a large percentage of them could have been taken with equal photographic success either on such a small plate as is used in various makes of hand camera or on larger ones such as half plate, but it should be noted that in most cases it would have been very much easier to obtain good results by using the smaller plate, partly on account of the great depth of focus of the short focus lens fitted to small cameras, and partly by reason of the greater number of alternative exposures which it is generally possible to allow when carrying such small apparatus. With regard to the focal length of lenses, it may be pointed out that, although those of short focus possess the advantage of depth of focus, with the accompanying power of giving short exposures at full aperture, this is in many cases more than counter-balanced by the necessary accompaniment of exaggeration of perspective which makes their use inadmissible for such subjects as field crops and experimental plots. On the other hand, for photographing live-stock, especially single specimens, and in cases in which an object in the foreground is to be the subject of interest, a small camera and short focus lens has many advantages, especially when lantern slides are to be made, which can then be done direct without reduction. When views of more extended subjects are required a more just appreciation of the relative sizes of objects in a picture is of course obtained by the use of a long focus lens, and it may be said that for a large class of subjects the use of a telephoto lens will give results very much superior in every respect to those obtainable with the ordinary lens whose focus bears the usual ratio to the diagonal of the plate. Moreover the modern telephoto lens is no longer the

PLATE XIV.

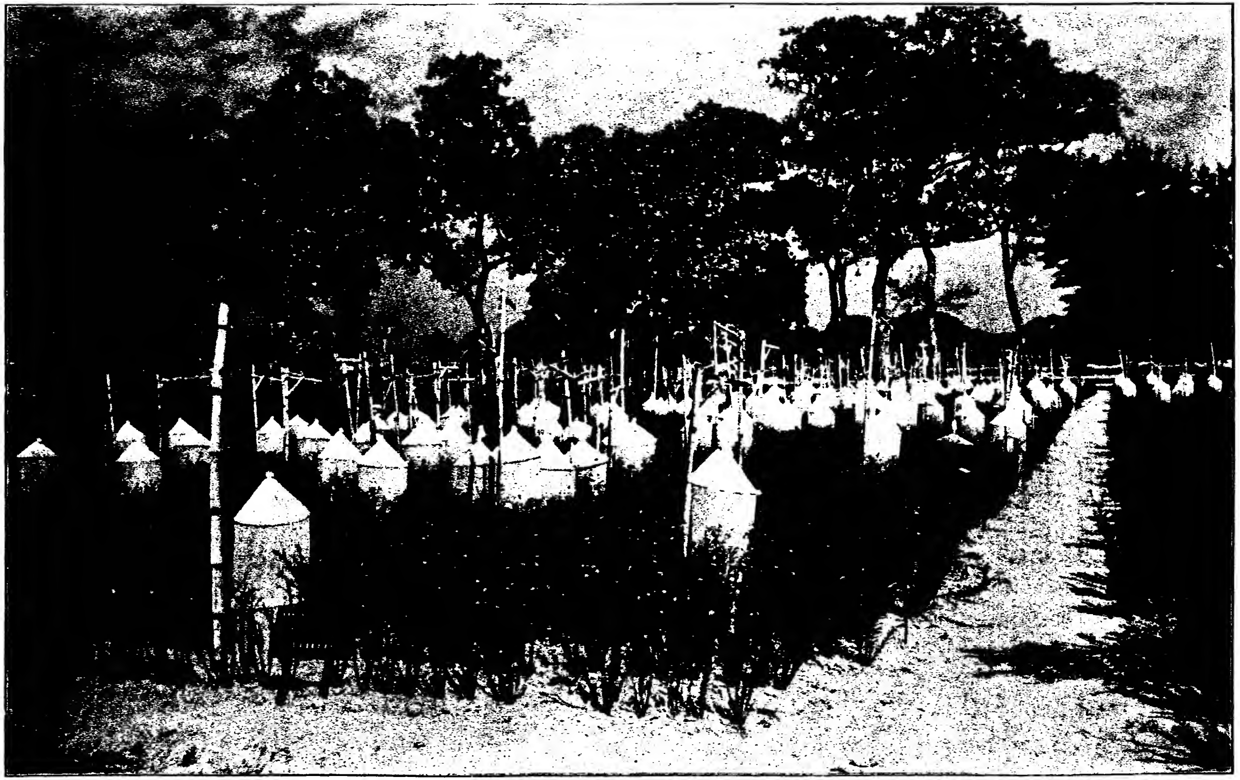
LINSEED PLOTS.



ILFORD ORDINARY.

Photo-Engraved & printed at the Offices of the Survey of India, Calcutta, [illegible]

LINSEED PLOTS.



WRATTEN M PLATE AND YELLOW SCREEN. (WRATTEN K_1.)

To show value of Orthochromatic Plate for rendering detail in green crops.

cumbersome and complicated addition to the camera of a few years ago, but is self-contained, not unduly heavy, and is simple to use; it must not be supposed that its only value is for taking objects necessarily distant; its use for the photography of field crops allows of the representation on the same plate of adjacent plots under differential treatment or bearing varieties of crops, without destroying comparison or contrast by the introduction of the exaggerated perspective almost inseparable from the use of the ordinary lens. A further advantage of the telephoto lens lies in its use for photographing single objects, such as plants, in such a way as to separate them from their surroundings, especially the background. This is the natural result of taking a large scale photograph of such an object with a telephoto lens, which, owing to its design, fails to define any objects except those lying in the single plane for which it is focussed, when used at a large aperture and brought near the object. In the many cases, where the use of an artificial background screen is impossible or difficult, this property is of great value, especially when half-tone is to be used, as any slight differentiation of the background from the subject which may exist in a photograph, is frequently lost in this method of reproduction.

It must be remembered that in reproducing a photograph for illustration it frequently happens that reduction in size of the original is effected in order to save space. In choosing the size of camera and plate this fact should be kept in mind, as whole plate photographs are very generally reduced to half plate size with accompanying loss of detail, so that it may be suggested that the use of a half-plate camera will generally be found advisable in preference to the larger size.

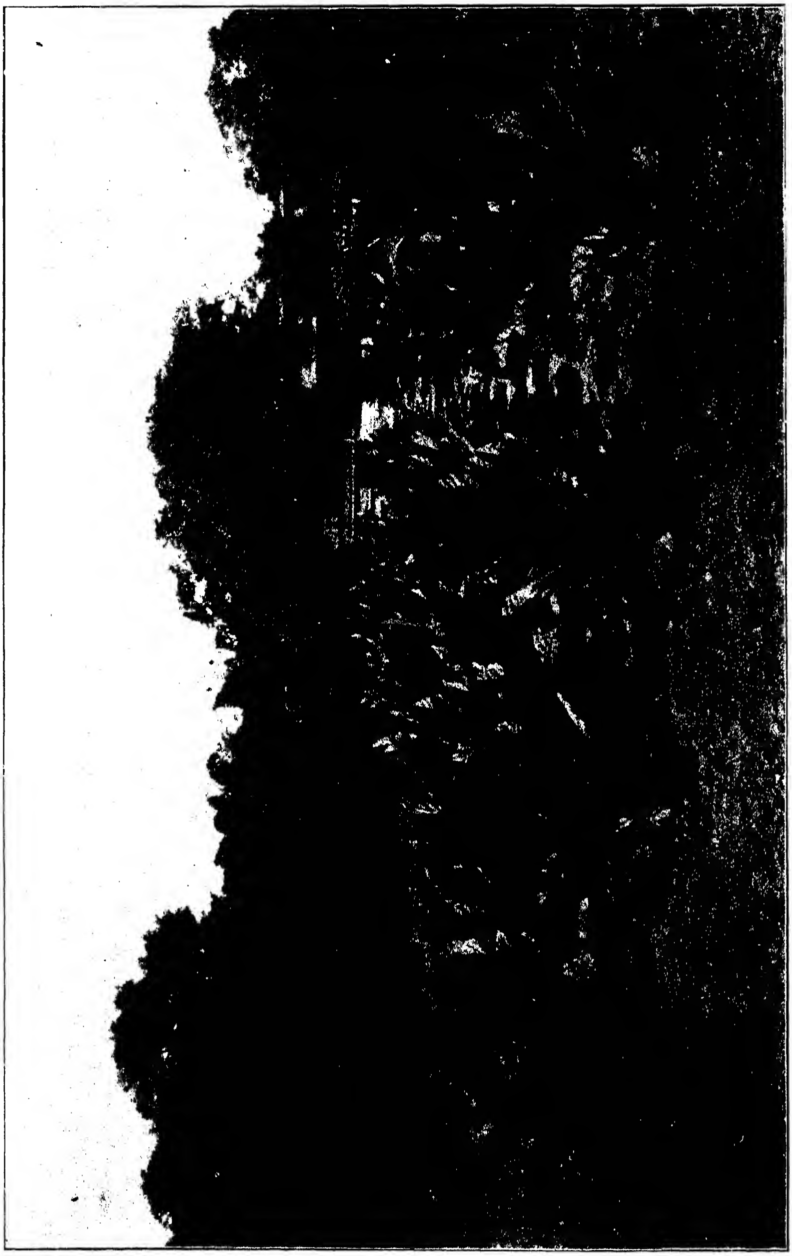
Whilst dealing with lenses it may be well to point out a fact in connection with the use of modern anastigmats which may not be generally known. It is very natural for the photographer to assume that having paid a long price for a good lens, such as an anastigmat, he will find it easier to produce good results than with the old-fashioned Rapid Rectilinear. In England this is generally the case, but in India, where most of our photographs are taken in bright sunlight, we not only lose the principal advantage of the anastigmat, which is designed to enable pictures to be taken in

comparatively poor light by the use of large apertures, but also encounter the disadvantage of "flare;" this is, roughly, the intrusion of sky light by internal reflection in the lens, into parts of the picture where it should not appear, the result in bad cases being patches of light known as flare spots, and in less pronounced ones of general light fog, which gives the impression of over-exposure when developing, and causes many photographers to stop development too soon to allow of the production of contrast. This effect can be avoided by sufficient care in selecting the point of view with reference to the position of the sun, but it may most easily be overcome by the use of an auxiliary lens-hood, the ordinary one supplied with most anastigmats being made, for appearance sake and convenience, much too shallow for safe use in this country. This accessory may be described as almost indispensable in outdoor work in India in connection with most anastigmats, especially when working at or near full aperture.

The advantages of using backed plates are so well known that it is unnecessary to do more than say that many photographers admit their utility but do not use them, partly on account of difficulty in obtaining them, but largely because of fancied trouble in developing them; the latter is really inconsiderable with a good make of plate which can be put straight into the developer without removing the backing, this being got rid of whilst rinsing the plate before fixing. On the other hand, the very great superiority of negatives of outdoor subjects including any strong high lights and still more so of photomicrographs, when taken on backed plates, renders their use almost imperative for such subjects, and not only for interiors including windows, or trees and shrubs against the sky.

Orthochromatic Plates. It is unnecessary to say anything as to the theory underlying the use of orthochromatic plates, but it may be of interest to give some examples of their value, and indeed of their occasional indispensability in illustrating such subjects as are photographically reproduced in agricultural publications. Incidentally it may be remarked that many orthochromatic plates now on the market have a very limited value owing to their comparative insensitiveness to the yellow and red end of the

TOBACCO.



ILFORD ORDINARY.

TOBACCO.

WRATTEN M PLATE AND YELLOW SCREEN (WRATTEN K_3).

This is a very difficult subject on account of the heavy shadows on the leaves. It will be seen that these are much more accentuated by the ordinary plate for reasons described in the text.

spectrum, and, where orthochromatism is an advantage, as it is in such a large percentage of cases, it is nearly always worth while to make use of a panchromatic plate. Given correct exposure, a clock, and a thermometer, no more difficulty need be experienced in the development of panchromatic plates than of any others of the orthochromatic variety, and although, as has been pointed out before, the ordinary plate of slow speed is easier to use and may be generally recommended for this reason, no scientific worker will be satisfied to use such plates when convinced that the best photographic representation of an object can only be obtained by means of an orthochromatic plate. Using a panchromatic plate, a light filter may be selected which will correct the superior actinic power of the blue end of the spectrum so as to give correct visual rendering of the subject. Thus in Plate XI fig. (b) the yellow of the butterfly wing is brought out by the use of a deep yellow screen; similarly in Plate XII fig. (b) the black fungal spot on the yellow leaf requires similar colour correction.

In some cases over-correction may be necessary to ensure the appearance of slight colour differences which would otherwise disappear in half-tone reproduction. Plate XIII fig. (b) shows such over-correction due to the use of a red screen; had a yellow screen been used the difference between the ripe and unripe crops although obvious in the negative would not be so in the half-tone reproduction.

One of the most valuable properties of the orthochromatic plate is its power of improving the representation of a field crop without special reference, as in the above cases, to obvious colour differences. This is shown in Plates XIV and XV. It may be of interest to point out why this is so and the reason is made more clear by consideration of the second example (Tobacco Plates XVI and XVII.) Much of the light reaching the lens, in this case, has come through the thickness of the leaves of the crop and, as transmitted light, has undergone absorption, losing some of the blue end of the spectrum. For this reason the ordinary plate can make but little use of it, so that many leaves and portions of leaves which appear well illuminated in the orthochromatic plate are in deep shadow in the ordinary plate, owing to the absence of any large quantity of

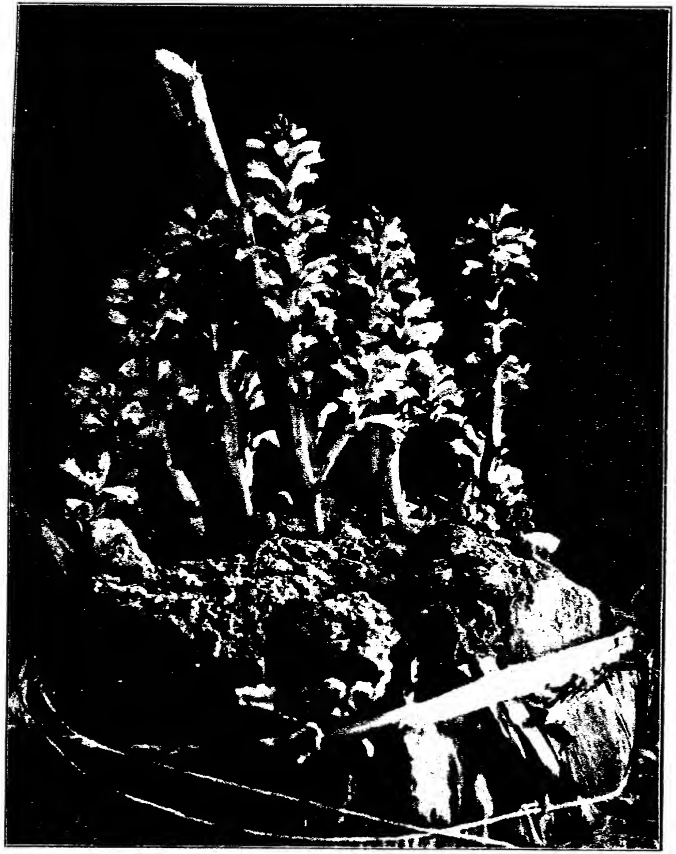
reflected light. It may perhaps be relevant to point out that an exposure of sufficient duration to give full value to these heavy shadows, would have resulted in over-exposure of the high lights. In this particular case the use of a panchromatic plate even without any filter would have given a better picture than the ordinary plate, but the additional correction afforded by the yellow screen levels up the shadows and tones down the high lights. A further difference between the rendering power of the panchromatic and the ordinary plate is due to the fact that the light coming from shadowed portions of such subjects as the above is frequently less rich in blue rays and will consequently have less actinic value.

It is useful to remember that orthochromatic rendering may be spoilt by over-correction which may result in *isochromatism*, that is by giving all the colours of the subject an equal luminosity value and thus producing an unnatural effect. This is illustrated in Plate XVIII where the best rendering is obtained on the ordinary plate, the yellow screen used in fig. (b) being too deep in tone and, by reason of its sharp cutting out of the blue end of the spectrum, producing over-correction, and as described above, reducing the shadows in this case to insignificance.

Where adequate representation of an object depends upon accentuation of shadow detail and of contrast between light and shade rather than upon orthochromatic rendering, the use of colour sensitive plates should be avoided as tending to flatten the object by reducing contrast. An example is given in Plate X where oblique illumination is also necessary to give solidity and relief to the representation.

Plate XIX illustrates the value of light filters for producing contrast in photomicrographic representation of objects including fine detail in thin sections, such as the cell walls in the subject reproduced, which without this aid are imperfectly represented. The selection of the appropriate filters must be made with reference to the stains used in the subject.

In conclusion it may be reiterated that for half-tone reproduction a really vigorous photograph is necessary and in order to obtain this the first essential is correct exposure. Until a large amount of



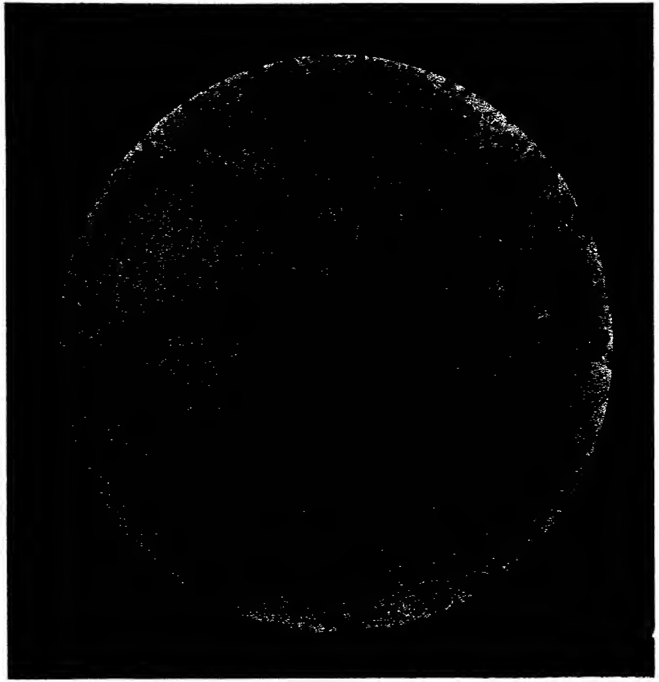
(*a*) ILFORD ORDINARY

(*b*) WRATTEN M PLATE AND YELLOW SCREEN (WRATTEN K_3).

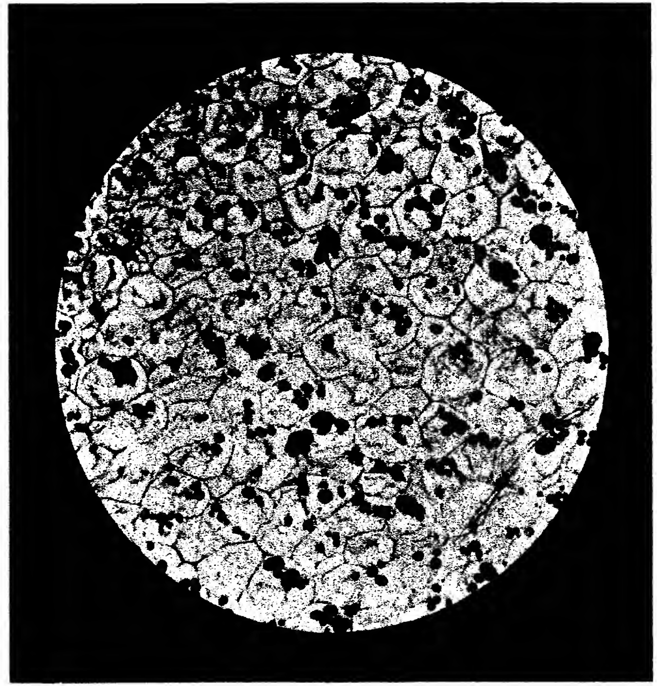
To show over-correction. This although a coloured object, can be rendered sufficiently well by an ordinary plate. The danger of over-correction due to use of a screen which cuts out the blue end of the spectrum too sharply, is illustrated by (*b*). Fine detail in the blue flowers was obtained by photographing through a blue screen (Wratten C) but the result is not published here, as it cannot be reproduced adequately in half-tone.

Photo.-Engraved & printed at the Offices of the Survey of India, Calcutta, 1916.

PHOTO-MICROGRAPH OF SECTION OF POTATO TUBER.



(a) NO SCREEN.



(b) GREEN AND YELLOW SCREENS. (WRATTEN B & E).

Stained Saffranin and Haematoxylin—Watson 16 m.m. object. Wratten M plate.

Photo-Engraved & printed at the Offices of the Survey of India, Calcutta, 1916.

experience of photographing subjects similar to the one to be reproduced has been obtained, no photographer can correctly estimate, by guesswork, the proper exposure, and the writer would suggest as absolutely necessary for attaining such experience, the use of a large number of alternative exposures with careful notes of the results; these notes should be kept for reference and use in the future and will be found invaluable. An exposure calculator such as the "Wellcome" supplied by Messrs. Burroughs Wellcome & Co., with their photographic note book, is also most useful, whereas exposure meters depending upon the use of light sensitive paper are practically worthless in India. Standardization of materials and methods by cutting down the number of uncertain factors is also of value; thus the invariable use of one make of each kind of plate required, one kind of developer, and even, so far as is possible, of one lens aperture, will be of help in obtaining results of even value. As a matter of personal experience the writer may strongly recommend the method of development advocated by Messrs. Wratten & Wainwright which does away with inspection of the plate during development, and depends merely upon carrying this on for a length of time determined by the temperature of the developer, the speed of the plate, and the class of negative required, in accordance with a table supplied with each box of plates by this firm. It is claimed that this method will give the best results irrespective of exposure, and with this claim the writer's experience ie in agreement; in addition it may be said that the error of under-development referred to previously will be avoided by this means. With regard to temperature and the special and very serious troubles connected with photography in India arising from this cause, it may be said briefly that when the developer temperature is high the use of pot. bromide becomes necessary and the use of such developers as metol and rodinal whose tendency to produce soft negatives is accentuated under these conditions, is of doubtful expediency. Alum should be freely used, but if ice is available it must be remembered that although a low temperature developer is an advantage, the tendency to frilling is greatly increased by any serious differences in the temperatures of the various solutions through which the plate passes.

THE MANURIAL VALUE OF POTSHERDS.

BY

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1. Introduction.

In previous papers,[1] dealing with certain aspects of soil aeration and surface drainage in India, reference has been made to the effect of adding to the soil porous substances such as potsherds (*thikra*) and fragments of bricks (*rora*). The occurrence of such materials, in sufficient quantity, in a fine alluvial soil has been found at Pusa to exercise a profound influence on the development of the plant and on the yield. Grown on such soils, leguminous crops like gram (*Cicer arietinum*) and Java indigo (*Indigofera arrecta*) produce a deep and copious root-system with abundant nodules as well as heavy crops of well filled seed. Tobacco, when raised on soil rich in potsherds, develops a great mass of fine roots and a heavy yield of leaf. If green-manure is added to such land during the monsoon, the succeeding *rabi* crops benefit markedly.

The explanation suggested to account for these results is a simple one and is based on the fact that the roots of plants as well as the soil organisms require not only a large oxygen supply but also some means of getting rid of the large quantities of carbon dioxide they produce in the soil. Potsherds improve the aeration of alluvial soils and thus afford the means of an increased supply of oxygen and nitrogen in one direction and of the escape of carbon dioxide in the other. When a crop like *sanai* (*Crotalaria juncea*) is ploughed into the ground during the monsoon, a large amount of oxygen is

[1] Soil ventilation, *Bulletin 52, Agricultural Research Institute, Pusa*, 1915, and Soil aeration in Agriculture, *Bulletin 61, Agricultural Research Institute, Pusa*, 1916.

required to complete the decay of the green-manure and vast quantities of carbon dioxide are produced. If this decay is not completed by the time a *rabi* crop is sown, there is present in the soil another competitor for oxygen and another producer of carbon dioxide in addition to the soil organisms and the growing crop. Hence want of oxygen and excess of carbon dioxide may become limiting factors in growth and this would explain why it is that green-manuring so often fails on alluvial soils unless they are surface drained and unless the soil is rich in potsherds. Simple as is this explanation, its complete proof, by the ordinary methods of academic research, is not without difficulty. Several factors, interacting on one another, are involved in such investigations—the plant, the soil, the organisms in the soil, the amount of soil moisture present, the composition of the soil atmosphere in the pore spaces and the nature and amount of the gases and minerals dissolved in the water films surrounding the soil particles. Some of these factors are also influenced by the temperature. To trace the various changes in composition of the atmosphere in the pore spaces and of the dissolved gases in the thin films of water which bathe the root hairs of the plant are matters of the very greatest difficulty. Analyses of the air aspirated from the soil only tell us the average composition of the soil atmosphere. Such methods are obviously far too crude for investigating the changes in the gaseous content of the water films and the relations between this dissolved gas and the general soil air.

While the complete elucidation of the parts played by oxygen and carbon dioxide in the soil are likely to prove both time-consuming and laborious, the fact remains that a considerable amount of evidence exists in favour of the rôle of the potsherd as an aerating agent and of the practical value of this method of soil improvement. It is proposed to refer to a portion of this evidence in the present paper in so far as it relates to the manuring of crops.

2. The waters of Jais.

In February 1915, in the course of a journey through Oudh, some excellent tobacco cultivation was noticed near Jais in the

District of Rae Bareli. Jais is an old Mohammedan city, standing high above the surrounding plain and the mounds on which the town is built are composed of the remains of the ancient city of Udianagar. Large stretches of very fine tobacco (*N. rustica*) are grown on the lower land surrounding Jais and the crop is irrigated from wells. In the present year, I again had occasion to pass Jais and took the opportunity of examining the tobacco cultivation. The soil was rich in potsherds, derived no doubt from broken roof tiles and water pots, and the water used in irrigating the tobacco was said by the cultivators to be unfit for drinking but very good for this crop, in the growth of which they stated very little manure was used. This was remarkable considering the excellent crops and the fact that this plant will not thrive in the absence of abundant nitrogenous food materials. They said the well water was rich in saltpetre and that as many as fourteen waterings are often given to tobacco. A large sample of irrigation water was taken from a well standing in the centre of the tobacco area about a quarter of a mile from the nearest houses, the analysis of which has been carried out by Mr. J. Sen, Offg. Imperial Agricultural Chemist at Pusa who has also kindly furnished me, for comparison, with some analyses of well waters at Pusa. The results are as follows :—

TABLE I.

Analyses of well water from Jais and Pusa.

	Jais	Pusa
Magnesium carbonate	25 39	7·6 to 15·200
Calcium carbonate	—	15·9 to 25·000
Magnesium sulphate	10 80	Nil to 1·550
Calcium sulphate	45 50	—
Sodium sulphate	1 01	Nil to 8·300
Sodium carbonate	—	4·0 to 9·9.0
Potassium nitrate	34·57	Nil to 0·036
Sodium nitrate	16·55	
Potassium sulphate	—	1·8 to 5·400
Sodium chloride	45·27	0·9 to 1·600
Total solids	179·09	30·2 to 66·986
Ammonia (free)	0·0212	Nil to 0·032
Ammonia (albuminoid)	0·0143	0·004 to 0·039
Oxygen dissolved	0·7250	0·067 to 0·153

(The numbers refer to parts in 100,000).

Two facts stand out very clearly in these analyses—the high proportion of nitrates in the Jais irrigation water and the amount of dissolved oxygen. In comparison, the Pusa well waters are markedly deficient in these substances. The Jais wells are situated in land exceedingly rich in potsherds, where the aeration of the soil is copious and where there is abundant oxygen for the complete decay and nitrification of the organic matter. It is therefore easy to understand how this well water comes to be rich in nitrates and in dissolved oxygen and why it is so much valued for irrigating tobacco. At Pusa, on the other hand, the alluvium is fine and close and soil aeration is difficult. Here the well waters are poor both in nitrates and in dissolved oxygen and do not possess any particular manurial value. The Jais water, in addition to its high content of nitrates and oxygen, is also rich in potash. This can be accounted for, partly by the fact that in rural centres wood and cowdung are used for fuel and partly by the increased aeration of the soil surrounding the wells due to the quantity of potsherd present. There is considerable evidence for the belief that one of the functions of the fungi of the soil is to collect phosphates and potash for the use of the higher plants.[1] These fungi can only work in the presence of oxygen and therefore the better and deeper the soil aeration the more potash they collect and render available.

Irrigation water, rich in potassium nitrate, is by no means the only condition necessary for raising heavy crops of tobacco of good quality such as the Jais product is said to possess. The soil must also have the proper physical condition for abundant and rapid root development and its tilth must be such that it is not destroyed by frequent surface flooding. Moreover, the crop must be provided with sufficient phosphates as little manure is added to the soil. The presence of abundance of potsherds in the soil would prevent the destruction of the tilth by irrigation and would also facilitate thorough drainage and thus promote aeration. This in turn would provide the soil fungi with oxygen and thus assist indirectly in the collection of phosphates for the tobacco.

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[1] Marshall Ward, *Disease in Plants*, 1901, pp. 56 68.

The Jais tobacco fields can be regarded as a natural manure factory in which nitrates, potash and phosphates are produced in sufficient quantity for crops like tobacco, maize and poppy which are all grown on the lands in question. In spite of the fact that maize is followed by tobacco or poppy the same year and that a relatively small amount of manure is used, the tobacco crops are luxuriant and the cultivators are obviously prosperous and well-to-do. The sources of the nitrogen and minerals used by the crops are evidently the crop residues and the manure supplied for the maize crop. That this organic matter produces such excellent results is, in all probability, a consequence of the copious aeration of the soil produced by the great numbers of potsherds present. That the crops do not make use of all the nitrates formed is seen by the composition of the well water used in irrigation.

3. Some other Indian nitrate factories.

The potsherd area round Jais is by no means the only natural nitrate factory in India. Well waters, rich in nitrates, occur elsewhere near villages and towns in the plains of India and also in Gujerat.[1] In all cases the aeration of the soils round these nitrate containing wells is good and, in many instances, potsherds or brick refuse occur in large quantities in the immediate neighbourhood.

Natural nitrate factories are common in some tracts of India in the absence of wells. Thus in North Bihar, the manufacture of potassium nitrate is a well-known industry and as many as 20,000 tons of this substance are produced annually.[2] The saltpetre is formed in the so-called nitrous earth and is separated by the *nunias* from other salts which occur mixed with it. This nitrous earth is found mostly *on the high lands round the villages which contain potsherds or brick fragments.* The potassium nitrate is derived partly from organic matter and partly from the ashes of wood or cowdung produced in large quantities in the villages. The abundant soil aeration brought about by the potsherds provides the necessary oxygen for the soil organisms including the nitrate

[1] *Agricultural Ledger*, no. 14, 1895.

[2] *The Commercial Products of India*, 1908, p. 972.

producing bacteria. In the presence of organic matter, wood ashes and moisture and under temperature conditions which favour intense bacterial activity, nitrification is rapid and potassium nitrate is produced in abundance. The evaporation of the surface moisture during the dry season, combined with the rise of the subsoil water by capillary action, leads to an efflorescence of saline matter on the ground in which saltpetre is one of the chief constituents. Such accumulations of salts, rich in nitrates, largely occur in areas where potsherds are abundant and are naturally quite different from those met with in alkali lands. One factor, however, which obviously limits production, has hitherto been forgotten in considering these natural nitrate factories. This is the aerating value of the potsherd and the fact that without a copious air supply, rapid nitrification is impossible in the soils of North Bihar.

4. Some practical applications.

The practical applications of these facts to Indian agriculture must now be considered.

The manuring of wells. As is well known, there is a large area of intensive cultivation surrounding the towns and cities of India where large crops of vegetables, sugarcane and tobacco are grown under well or river irrigation. Manure is obtainable, and potsherds are abundant. The manure is usually added to the soil but no use is made of the potsherds. More could be got out of the present supplies of manure and this garden cultivation could be extended by dressing the land with the potsherds and by using some of the organic matter for manuring the wells. It would not be a difficult matter to make, in the soil round a well, a potassium nitrate factory the products of which could be directed either into the well itself or into the irrigation stream. The soil round the well would have to be mixed with the right amount of potsherds and organic matter and ashes would have to be added to the surface soil from time to time. The details would have to be worked out experimentally and then applied to actual working conditions. Possibly some Chemist in the Agricultural Department in search of an interesting problem might consider this question.

The permanent improvement of the land. It is evident that in the soils of India, the great factor in manuring is aeration and that Jethro Tull's great generalization that "Cultivation is manuring" can now be extended and summed up in the phrase—*Manuring is aeration.* The potsherd enables us permanently to aerate the soil and thus make the best use of organic matter including green manures. The potsherd by itself has only a limited value but with the help of small quantities of organic matter, extraordinary results are possible as the example of Jais is sufficient to indicate.

Preliminary experiments have already been completed in the Botanical Area at Pusa which prove that, in the growth of tobacco after green manure, the addition of potsherds to the soil is profitable. With potsherds and surface drainage, a yield of 24 maunds to the acre of cured tobacco leaf has been raised on green manure alone and the produce, cured on the ground in the country fashion, has been sold to the Indian Leaf Tobacco Development Company at Dalsing Serai for fifteen rupees a maund. The value of the crop was therefore three hundred and sixty rupees an acre. To prove the manurial value of potsherds however, something more than small trials at a Plant Breeding Station are required. Accordingly, arrangements have been made to treat ten acres of land on the Dholi estate with potsherds and to compare the produce of the land for some years with the initial capital cost of the treatment. There is little doubt that the results will establish this method of soil improvement and will suggest a useful means for the investment, in the soil of India, of much of the capital now lying idle in the country.

DRY-FARMING AND ITS POSSIBILITIES IN INDIA.

BY

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Foreword

Less than a generation ago the very large area of land in Western America, not susceptible of irrigation, was looked upon as practically worthless for agriculture. Since that time many millions of acres of these apparently inhospitable tracts have been converted into fruitful fields. This is due in part to the venturesome energy of the American people, but chiefly to the careful investigation of the natural conditions of the territory in question and the application to the land of well-known scientific principles, followed by further investigations leading to the discovery of other principles, of profitable application to the reclamation of non-irrigable arid lands.

Colorado established, more than eighteen years ago, a branch station for the study of dry-farming. Utah, a few years later, established a large series of experimental dry-farms, and inaugurated a series of studies on the relation of soils and crops to water. Other states have done similar work, and the Federal Government has conducted for some years very comprehensive dry-farming studies in the great plains area of the United States. On the basis of such work the American people have been able to conquer, without irrigation, much of the great territory lying under a light rainfall in what was formerly known as the Great American Desert.

In talking with students from India it has always seemed that, while the problems of India no doubt differ considerably from those

of western United States, the same process of careful study of existing conditions and the wise applications of scientific principles, old or new, should make it possible to make the agriculture of India, not under irrigation, much more certain than it has been formerly. The problem is a large one, whether in India or America, but the experience of western America leads most of us who have been engaged in the work, to believe that the methods of study followed so successfully in reclaiming the American arid lands may be employed with success wherever a low or uncertain rainfall is a determining condition.

Mr. C. V. Sane, the author of this paper, has spent much time in the dry-farming areas of the United States and has had unusual opportunities to become acquainted with the methods practised on American dry-farms and in dry-farming laboratories. His description of American dry-farming is accurate. He has emphasized the leading principles of the practice. It is to be hoped that the dry-farming regions of India may be helped by such studies and discussions as this one by Mr. Sane, and that especially they may lead to an enlargement of the scientific study of dry-farming under the conditions of India. We of the far west may thus learn much of the far east, and we still have much to learn.

LOGAN, UTAH, U.S.A.
October, 1915.

JOHN A. WIDTSOE.

Introduction.

OF the many things that compel the attention of agricultural investigators in India towards American agriculture, one thing that has done more so than any other is the system of dry-farming and its success in such a short time. By the very nature of things in most cases the little knowledge that we have on the subject is principally derived from books and consequently is very rudimentary. For though the principles of dry-farming are known all over the world the art of manipulating the soil so as to make it an economical practice is fraught with many difficulties. The necessity of dry-farming in India is becoming more and more apparent every day.

However, a detailed study of all the factors—chiefly soil and soil moisture—that are associated with its success in parts where it is an established practice should logically precede the undertaking of such an investigation.

The writer has not only made a careful study of the literature on the subject but has also had the privilege of conferring with persons whose opinions are an authority in the matter, in addition to visits and observations in the fields. A few figures dealing with mechanical analysis, moisture study, etc., have been introduced, for, apart from rainfall which can easily be ascertained, these are the most important factors, knowledge of which is not so easily available in India. They illustrate the basis and extent of the system and will prove of great help in laying out the work. For after all is said and done elsewhere the only way things can be answered definitely is by independent experimenting.

That dry-farming is a world problem is now universally conceded. The following table taken from "Dry-Farming" by J. A. Widtsoe illustrates this fact.

Character of farming	Annual precipitation	Proportion of earth's land surface per cent.
Arid	Under 10″	25·00
Semi-arid	10″ – 20″	30·00
Sub-humid	20″ – 30″	20·00
Humid	30″ – 40″	
,,	40″ – 60″	11·00
,,	60″ – 80″	9·00
,,	80″ – 120″	4·00
,,	120″ – 160″	0·50
,,	above 160″	0·50
		100

It will be seen that 55 per cent. of the land surface is under a rainfall of less than 20 inches; thus necessitating the adoption of dry-farming for the profitable growing of crops. It is estimated that about 10 per cent. more receives a rainfall of from 20 to 30 inches, making dry-farming essential. Thus a total of 65 per cent. is directly concerned in the methods of dry-farming. Only a very small portion of this area can ever be completely reclaimed by irrigation practices, leaving the major part of the world always interested in the movement of dry-farming.

The study of this system becomes even more imperative in countries like India where the rainfall over a portion of the country is not only short but extremely precarious, and when one comes to consider the amount of land in India which would benefit by a knowledge of dry-farming it becomes obvious that it is up to us to lose no opportunity of obtaining information which may assist us.

History, definition, and a few contentions regarding Dry-Farming.

Though America has the privilege of bringing dry-farming in limelight to-day, it is not to be supposed that it is a new system. It is rather a new name to a system which was practised in ancient days. Unmistakable proofs have been found to-day in all the ancient civilizations in China, Mesopotamia, Egypt, Mexico, Peru, etc., testifying that it was a practice in vogue in those days. Kearney[1] in a study of dry-land olive culture in North Africa quotes Tunis as an example of the extent to which it must have been practised in the old days. Though Tunis has a rainfall of only about 9 inches on an average, the ancient ruins are of such a nature that the territory was probably densely populated. No evidence of irrigation practice is found and the inference is that the territory must have been dry-farmed. But, however well known the art may have been in the past, the credit of reviving and awakening a general interest in this almost forgotten and neglected practice must be awarded to those American pioneers who wended their way westward and subdued the desert in their struggle for existence. The curious thing in this connection is that these methods were simultaneously and independently developed in Utah, California, Washington, and the Great Plains. However, to Utah belongs not only the claim of precedence in this respect, but also the credit of being the first to undertake a complete study of the behaviour of soil moisture which has given the system a scientific basis it enjoys to-day, mainly through the researches of Dr. Widtsoe and his colleagues.

[1] *Bulletin No. 125 of the Bureau of Plant Industry, U. S. Dept. Agri.*

Dr. Widtsoe defines dry-farming as the profitable production of useful crops without irrigation on lands that receive a rainfall of 20 inches or less. In districts of torrential rains, high winds, unfavourable distribution of rainfall or other water dissipating factors, dry-farming is also properly applied to farming without irrigation under annual precipitation of 25 or even 30 inches. A large part of the dry-farm territory in India will fall into the latter category where conditions of water dissipation are far more pronounced in every particular than the worst that could be obtained in the United States.

Even in the United States, however, there is a considerable difference of opinion regarding the best way of applying the principles of dry-farming to soil management. There comes in the wake of every scientific discovery a time when undiscerning and unscrupulous persons make unwarranted generalizations with consequent failures and confusion, and in a country so much given to speculation and exploitation it must have assumed rather serious proportions to compel the Federal Department of Agriculture to caution the uninformed public against some misconceptions which it would be well to quote here

" In conclusion, the following misconceptions concerning dry-farming may be mentioned as among the most serious : (1) That any definite 'system' of dry-farming has been or is likely to be established that will be of general applicability to all or any considerable part of the Great Plains area ; (2) that any hard and fast rules can be adopted to govern the methods of tillage or of time and depth of ploughing ; (3) that deep tillage invariably and necessarily increases the water-holding capacity of the soil or facilitates root development ; (4) that alternate cropping and summer tillage can be relied upon as a safe basis for a permanent agriculture or that it will invariably overcome the effects of severe and long-continued droughts ; and (5) that the farmer can be taught by given rules how to operate a dry-land farm."[1] It is well to keep these in mind in India also.

[1] *Year-Book of the United States Department of Agriculture*, 1911, p. 256.

Some noteworthy facts regarding American agriculture.

An agricultural specialist from America, who had been in India as recently as 1914, observed to the writer that the one thing that struck him more than anything else while there was the very poor physical condition of the soil, an observation that is entirely true. By contrast the condition of American soils ready for planting is almost perfect. But this is due more to the suitable climatic conditions by which good physical condition and preparation of the soil can be secured easily and cheaply. Even if the worst came to the worst the soils here over the major part of the continent never dry out or bake so hard that cultivation becomes impossible after the crops have been off the ground for any length of time. As an additional help there are the autumn rains followed by the snow. If conditions do not allow the autumn ploughing of the soil, as the snow thaws in the spring, the soils come in just an ideal condition for preparatory tillage. It is this factor that makes preparatory tillage so easy in America. On the other hand in India where the crops come to maturity, not so much on account of low temperature as is the case here, but due to the sheer lack of water, the roots dry up the soil in such a wholesale fashion that cultivation becomes only possible if attempted below the zone of block formation which is in many cases more than a foot deep, and even after this, the soil never falls into that crumbly condition so essential for good cultivation. Even granting that a deep ploughing is conducive to a better physical condition and a better absorption of water than no ploughing, the only way it could be accomplished is by machine ploughing, which under the present condition of agriculture does not seem easily possible or profitable either. In India we have practically only two sowing seasons : the *kharif* and *rabi*, but these are usually not co-existent, being found in widely separated territories, so that there is but one sowing season in a particular locality and since the farmer is always afraid of a short season the sowing of all crops has to be done post-haste in order that the crops may have a chance to mature. Any one connected with agriculture in India knows how feverishly hurried these operations are. As a contrast,

here in America the farmer is practically farming all the year round, and often starts his crop the year before, as in the case of winter wheat, clover, or sowing in the growing crop in the fall, *viz.*, cowpeas in corn or cotton, etc. Thus he sows his wheat in autumn, it grows a little and rests during the winter under the snow. In spring, when the snow thaws the wheat begins to grow again. In spring, he may sow rye, oats, or barley and seed down the field to clover which may occupy the land from year to year. Different seasons for sowing corn, potatoes, tobacco, clover, wheat and other crops are possible owing to the moisture conditions being such that a great variety of crops could be grown, resulting in the most profitable use of the farmer's time, and in winter, when field operations are at a standstill, he attends to his dairying or stock feeding. Thus conditions are rarely so devoid of the necessity of doing any agricultural work as they are in India with a growing season of only three or four months in each locality, and hard, hot dry weather for the rest of the year preventing crops being taken from season to season under dry-farm conditions.

Other factors are the size of the farms, their contiguity, the presence of the farmer on his estate, the business and competitive condition of farming, the supply of effective machinery, and the large capital available to the farmer for investment. All of these are important, but the peculiarity of the season as explained above, the possibility of distributing crops over a large period and above all the absence of social or religious prejudices such as crop up in every attempt at improvement in India are matters that are not so well realized there and hence are grouped under a separate heading to give them the proper emphasis.

Basis of Dry-Farming.

The theoretical consideration of dry-farming becomes only possible after the water cost of the dry matter is worked out. Extensive researches have been made in this respect by Wollny and Hellriegel in Germany; by Lawes and Gilbert in England; by King and Widtsoe in America and Leather in India. With the exception of Drs. Widtsoe and Leather the rest have obtained

their results under comparatively humid conditions. Making allowance for the excessive use of water used in his work Dr. Widtsoe places the average water cost per pound dry matter at 750 pounds. A dry crop of wheat in India normally yields about 600 pounds of wheat per acre and taking roughly the same weight to represent straw we have a total weight of 1,200 pounds dry matter. The amount of water required for this yield of grain and straw would be 900,000 pounds at the rate of 750 pounds of water to the dry pound. Since one inch per acre is equal to 226,875 pounds the amount of rain actually used by the crop is about 4 inches per acre. There is no doubt that the farmer will be more than satisfied if he can raise 600 pounds of wheat every year with certainty and since the amount actually required represents only from 15 to 20 per cent. of the average rainfall, there is no reason why with better methods of handling the soil than are now in vogue, larger yields could not be secured in normal years or profitable ones in poorer seasons.

It is well known that all the moisture present in the soil is not available to plants. It is only that portion of the soil moisture which can freely move under the force of capillarity that is useful for good plant growth. The point below which the moisture in the soil is not available to crops is designated the wilting co-efficient and the extensive researches of Briggs and Shantz,[1] show that this is a soil constant and bears a constant relation to the hygroscopic co-efficient of the soil and is higher or lower according to the type of soil. Up to a certain percentage beyond this wilting co-efficient even, the water moves with some difficulty and does not replace what is used by the crop as readily. This point, Dr. Widtsoe[2] suggests, should be called Lento-capillarity. In the particular soil he was dealing with he found it to be 12·75 per cent. It is only the difference between this and the field capacity of the soil for holding water that can be safely relied upon for plant growth. The field capacity of the soil does not necessarily come to its maximum capillary capacity owing to the constant pull of gravity. It has been put at 19 per cent. in a clay soil to a depth of 8 feet;

[1] *Bulletin No. 230 of the Bureau of Plant Industry, U. S. Dept. Agri.*

[2] *Bulletin No. 115, Utah Agri. Experiment Station,* p. 230.

18 per cent. for the clay loam ; 16 to 17 per cent. for loams and 14 to 14·5 for sandy loams. Considering 7 per cent. as a fair percentage of readily available moisture one acre foot of soil with a weight of 3,500,000 pounds will supply 245,000 pounds of water and a depth of 4 feet of soil would give 980,000 pounds of available water and referring to calculations previously made, a uniform depth of 4 feet of clay loam or loam soil will hold enough moisture to give 600 pounds of wheat per acre. So much, however, depends upon the uniformity of the soil, depth, and its moisture capacity that it is idle to speculate any further until a study of these factors is made actually on the spot and results obtained.

Factors underlying Dry-farming.

The success or failure of dry-farming methods depends on the resultant of the two opposing forces of precipitation and dissipation. Where this margin is large enough for crop production and can be obtained at a reasonable cost, dry-farming will be a success. The system would not be economical though possible where the cost for obtaining this margin will be such as to seriously interfere with the profits. Conservation of moisture at reasonable cost is, therefore, the basis of the system. The positive factors in this retention of moisture are the soil and rainfall and the opposing forces are evaporation, seepage and surface-wash.

Owing to the tropical climate in India over a large part of the year the losses due to evaporation depending upon temperature, sunshine and winds are far more serious than in the cooler climate of the United States. The loss due to seepage is very slight, if any. Owing to the cyclonic and torrential character of the rain, however, our greatest loss in India is in the surface wash, when not only the rain but a considerable proportion of our best soil also is lost with it. There are no figures at hand showing what proportion of rainfall is lost in this way in India but observations made by Briggs and Belz[1] in this country show that as high as 80 per cent. of rainfall of 2·5 inches falling in 4 hours on a nearly level summer fallowed

1 *Bulletin No. 188 of the Bureau of Plant Industry, U. S. Dept. Agri.*

field was lost by run-off. The only thing that partly compensates for these heavy losses is the comparatively larger rainfall, but whether it is large enough to allow this loss can only be determined by actual tests.

Conditions for water conservation are ideal in Utah where the dissipating forces are comparatively feeble and the character of the precipitation and soil is such as to give maximum efficiency for storing water.

It may be mentioned here that crops in these highly developed dry-farming regions do not depend on one, two or even three feet of soil but search down to a depth of 8 feet or more in the soil in quest of moisture. Not only has moisture percentage been found to have been affected to this depth but wheat roots have actually been traced to a depth of 8 feet. Observations in North Dakota and Nebraska, though different in other respects, show that roots can feed to a depth of 6 feet positively, and possibly at lower depths. It is this deep rooted habit that enables the crop to yield at the rate of 900 pounds of wheat per acre on an average, on a rainfall of less than 15 inches; and crops of 3,000 pounds of wheat to the acre have been raised while 2,400 pounds is not at all unusual.

These factors of the uniformity and depth of the soil which are so essential for success in dry-farming are often lost sight of or not as well emphasized as they ought to be in other parts where attempts at dry-farming are being contemplated.

The subject of soil moisture has nowhere been studied as completely as in Utah and most of the figures reproduced here are therefore drawn from the investigations at the Utah Agricultural Experiment Station.

Professor Chilcott who is in charge of the Office of Dry-land Agriculture of the United States Department of Agriculture divides the dry-farming area in America in two sections—(1) The Great Plains and (2) The Great Basin or Inter-mountain. The Great Plains area lies principally between the eastern slope of the Rocky Mountains and Missouri-Mississippi Valley. It was in this area that the early reverses were experienced and it is this area where a few of the misconceptions quoted above took shape. It is characterized by a scanty winter precipitation, the bulk of the rains coming in May, June, and July.

The Great Basin or Inter-mountain Region lies between the Rockies and the Sierra Nevada Mountains and the precipitation, though usually less in amount, is chiefly received in the winter and spring, leaving the summer rainless. It is in this region that dry-farming was first found successful and subsequently developed to its present magnitude.

Though the moisture study has been made in various parts of the Great Plains and the Inter-mountain Region, the soil study is nowhere as completely done as in Utah. The following table[1] shows the approximate mechanical analysis of the various kinds of soils where dry-farming is successfully practised in this State.

Average mechanical analysis to a depth of 8 feet.

County	Coarse matter	Sand	Clay
Iron County	4·55	31·79	11·91
Juab ,,	6·07	29·53	15·69
San Juan	0·87	56·46	9·15
Sevier	31·31	55·31	11·84
Tooele	7·28	38·65	12 91
Washington	16·28	53·86	10·16

It will be seen that quite a variety of soils can be utilized under the dry-farming system.

The great uniformity of the soil can be seen from the following table[2] representing a depth of 8 feet.

Juab County Farm.

Size of particles	Soil separate	1	2	3	4	5	6	7	8
	Coarse matter ...	9·59	5·29	8·94	4·43	5·85	2·20	3 64	3·93
	Fine matter ...	9)·41	94·71	91·06	95·57	94·15	97·80	96·36	96·07
0·1—0 32 mm. ...	Medium sand ...	8·93	8 99	8 73	11·36	15 69	8 93	16·28	12·60
0·032—0·1 ,, ...	Fine sand ...	20·05	16·48	12·38	18·87	19·48	27·40	25·00	22·52
0·01—0·032 ,, ...	Coarse silt ...	21·97	19·75	22·53	19·06	23·88	22 27	21·88	21·91
0·0032—0·01 ,, ...	Medium silt .	15·23	16·78	17·53	17·25	15·43	13·51	13·73	17·03
0·001—0·0032 ,, ...	Fine silt ...	13 25	14·88	14·47	18·93	8·01	7·11	8·68	9·74
less than 0·001 mm. ...	Fine clay ...	15·73	16·88	18·62	20·68	12·41	10·03	12·18	13·29

Soils in the Great Plains area are more variable in character and depth and where shallow or under-lain by a porous sub-soil, results in the conservation of moisture are discouraging.

[1] *Bulletin No. 104. Utah Agri. Experiment Station.*
[2] *Bulletin No. 122, Utah Agri. Experiment Station.*

The limits of soil types in a section of the Great Plains[1] area are as follows :—

Size of particles	Soil separate	1	2	3
1 mm. and above ...	Fine gravel	...	...	...
0·5—1 mm.	Coarse sand ...	0·1-0·4	0-0·2	0-0·1
0·25—0·5 „	Medium sand ...	trace-0·3	0-0·3	0-0·1
0·1—0·25 „	Fine sand ...	1·5-14·1	1·4-12·3	1·6-9·2
0·05—0·1 „	Very fine sand...	43·1-52·5	37·8-55·4	42·7-58·2
0·005—·05 „	Silt	36·1-43·6	32·5-42·7	30·4-45·8
less than 0·005 mm.	Clay ...	5·8-10·5	6·7-11·7	8·1-13·3

The importance of having uniform and deep soils can hardly be over-estimated when it is realized that it is the depth which has made the growth of remunerative crop possible ; by the deep roots they send out in search of moistur That the storage of moisture affects to a depth of 8 feet at leas d possibly further can be seen from the table[2] reproduced belov

All moisture percentage on the basis of dry soil.

Season (after)	Date	1	2	3	4	5	6	7	8	Average
Harvest	Sept. 8, 1902 ...	6·37	7·32	8·17	8·55	8·26	9·29	10·10	10·38	8·56
Storage	Apr. 24, 1903 ...	19·29	19·08	18·83	16·99	13·61	12·62	12·24	12·37	15·63
	Increase ...	12·92	11·76	10·66	8·44	5·35	3·33	2·14	1·99	7·07
Harvest	Aug. 24, 1906 ...	8·33	7·63	8·42	9·66	11·30	10·75	9·59	7·93	9·20
Storage	May 11, 1907 ...	18·17	16·73	17·96	16·88	16·59	16·25	14·98	13·48	16·38
	Increase ...	9·84	9·10	9·54	7·22	5·29	5·50	5·39	5·55	7·18

It has been estimated that on an average more than 60 per cent. of the precipitation could be stored in the soil to a depth of 8 feet in Utah. Burr[3] working on the Western Nebraska soil in the Great Plains area has found that, if properly cared for, the summer-tilled or summer-fallow soils showed from 5 to 7 inches more water in the first 6 feet of the soil than similar land growing a crop and the water so stored has been equal to from 40 to 50 per cent. of the rainfall for the same period. Further that the moisture content of the summer-tilled land increases below the 6 feet area and is apparent to a depth of at least 10 feet.

[1] *Bulletin No. 114, Nebraska Experiment Station.*
[2] Widtsoe, *Dry-Farming*, p. 114.
[3] *Bulletin No. 114, Nebraska Experiment Station,* p. 51.

It is a general impression that soils to be retentive of moisture must be either clayey, clay loams or at least silty loams. That such is not however the case, in fact, a lighter kind of soil is more amenable to dry-farming, is the observation of many.

Professor J. W. Powell in his book "Arid Lands" states that a sandy soil seems to be an essential condition for dry-farming.

Recently Clothier[1] working in Arizona found that "The lighter types of soil have proved to be more valuable for dry-farming than the heavier ones."

That sandy soils are not debarred from dry-farming methods can be seen from actual determinations of soil moisture presented in the following table[2] :—

Proportion of rainfall stored in the soil.

Soil Type	Percentage of water in soil in autumn (after harvest) depth of 8 feet	Rainfall during the period of conservation in inches	Percentage of precipitation found in the spring to a depth of 8 feet
Sandy loam	8·78	8·51	[illegible]7·59
,, ,,	7·87	7·94	95·56
,, ,, ..	8·83	12·14	82·61
,, ,, ..	9·10	16·17	62·77
,, ,, ...	11·03	6·38	67·55
Clay	12·34	10·51	93·17
Sand ..	7·73	7·27	64·80
Loam	11·04	10·65	81·13

The observation that lighter types of soil are more suitable to dry-farming is possibly due to the fact that the heavier soils though they have a large moisture percentage, actually allow a smaller supply to the feeding roots, owing to the wilting co-efficient being higher in the heavier soils than the lighter ones.

Burr working with the Western Nebraska soils has found that water above 7 per cent. of the soil only is available to crops. Taking 17 per cent. as the field capacity of the soil, the portion available would be 10 per cent. (17 – 7 per cent.).

The wilting co-efficient of a clay will be somewhere about 11 per cent. and taking its field capacity at 19 per cent. there will

[1] *Bulletin No. 70, Arizona Agri. Experiment Station*, p. 797.
[2] Widtsoe. *Dry-Farming*, p. 121.

be left only 8 per cent. as available moisture. Add to this the effect of the lento-capillary water, the ease with which the roots can penetrate the lighter soils and one can see the reason of the observation under consideration.

So far as the chemical composition is concerned the soils appear to be richer in phosphorus and organic matter. In the following table[1] are given the limits of the percentages in the various dry-farming sections in Utah as compared to a few from India :—

Results expressed as percentage in dry soil.

Ingredient	1st foot	4th foot	9th foot	India[2]
Insoluble residue	52·14—88·25	52·38—78·29	46·47—86·87	65·16—88·08
Potash K_2O	0·55— 1·31	0·45— 0·80	0·42— 0·70	0·14— 1·14
Soda Na_2O	0·14— 0·44	0·30— 0·52	0·42— 0·70	0·01— 1·30
Lime CaO	0·56—18·97	3·21—17·83	0·79—20·22	0·13— 3·43
Magnesia MgO	0·42— 2·24	0·59— 2·66	0·75— 2·93	0·22— 2·47
Sulphuric acid SO_3	0·05— 0·13	0·05— 0·17	0·07— 0·11	not determined
Oxide of Iron Fe_2O_3	2·80— 5·42	2·26— 5·23	2·36— 3·02	2·46— 9·27
Alumina Al_2O_3	2·29— 6·33	0·14— 6·47	3·36— 6·62	1·74—13·76
Phosphorus P_2O_5	0·23 – 0·419	0·12— 0·356	0·10— 0·284	0·00— 0·23
Carbon dioxide CO_2	0·23—18·55	2·04 – 15·12	0·14 – 20·08	0·11— 1·88
Volatile matter ...	3·02 – 5·31	2·79— 4·42	1·62— 2·93	0·24— 6·58
Humus	1·09— 1·63	0·50— 1·69	1·15— 1·35	not determined
Nitrogen	0·057—0·116	0·037—0·1	0·018—0·05	0·015—0·24
Total P.	0·191	0·181	0·112	not determined
Total K.	2·32	1·48	1·30	......

A. Rainfall and its conservation.

In spite of the lower amount of total precipitation, mention has already been made that dry-farming in the Great Basin has proved more successful than the Great Plains area. This is due to the character of the rainfall, more than 80 per cent. of the rainfall in the Great Basin being received as winter and spring rains while more than 60 per cent. in the Great Plains falls after the crops have been sown and over 30 per cent. in summer. The following table shows the average seasonal distribution of rainfall in the two regions :—

Region	Rainfall	Percentage in fall after harvest	Percentage in winter mostly snow	Percentage in spring	Percentage in summer
Great Basin ..	14·53—19·07	16	23	42	19
Great Plains ...	11·92—21·30	12	9	43	36

[1] *Bulletin No. 122, Utah Agri. Experiment Station.*
[2] Hilgard. *Soils*, 1912, p. 412

It will be seen that the Great Basin receives 23 per cent. of its precipitation as snow against only 9 per cent. in the Great Plains and it is doubtful if there could be a more ideal condition of storing water if the land is well prepared than the snow, which, as it melts in the spring, gradually seeps through in the soil deep down with no run-off, evaporation, or seepage to speak of. The rainless summer prevents any tendency on the part of the crop to develop surface feeding roots and the plant thus uninterruptedly follows the moisture deep down into the soil.

As regards summer rains, the factors of dissipation in the form of run-off and evaporation are most active at the time the rains come. Besides, while a rainfall sometimes may help to pile the annual average it may not be of any use in increasing the soil moisture—a condition to which we in India are well accustomed. Briggs and Belz have observed that a monthly precipitation of 1·9 inches coming in nine light showers was of no practical value, as it all evaporated before penetrating the surface mulch. It has been repeatedly[1] observed that even a rainfall of half an inch does not add to the moisture supply unless followed by others within ten days. As a compensating circumstance, however, of light summer showers, is the fact that a rainfall of from quarter to half an inch may have a decidedly beneficial effect on the crop, though it again becomes a double-edged sword, since it tends to encourage surface roots and in the case of long dry periods specially at a critical period when water is being fast used by the crop, the crops would not have enough time to send down deeper roots and may receive as a result a serious check or possibly end in failure.

It appears that in the long run it would be better if such light showers were prevented from having any effect on the crops in encouraging surface rooting, by deep intertillage, and though it might result in a temporary check to plant growth, the ultimate safety of the crop could be more safely assured in case of the long dry periods, which are only too prone to occur in India at some stage of the crop.

[1] *Bulletin No. 70, Arizona Agricultural Experiment Station*, p. 738.
Bulletin No. 114, Nebraska Experiment Station, p. 51.

Dr. Widtsoe in summing up the subject says : " A great deal has been said and written about the danger of deep cultivation because it tends to injure the roots that feed near the surface . . . True, deep cultivation when performed near the plant or tree, destroys the surface feeding roots, but this only tends to compel the deeper lying roots to make better use of the sub-soil. When, as in arid regions, the sub-soil is fertile and furnishes a sufficient amount of water, destroying the surface roots is no handicap whatever. On the contrary in times of drought the deep lying roots feed and drink at their leisure far from the hot sun and withering winds and the plants survive and arrive at rich maturity while the plants with shallow roots wither and die or are so seriously injured as to produce an inferior crop.

" One of the chief attempts of the dry-farmer must be to see that plants root deeply. This can be done only by preparing the right kind of seed-bed and by having the soil in its lower depths well stored with moisture, so that the plants may be encouraged to descend. For that reason an excess of moisture in the upper soil when the young plants are rooting is really an injury to them."

B. Absorption and retention of moisture.

Deep ploughing with subsequent tillage and in parts where the rainfall is below 12 inches, summer fallowing to carry over the supply of moisture from one to the other season are the two principal means used for storing water. Nearly all the contradictions with regard to the dry-farming system that have arisen are with regard to these two factors—deep ploughing and summer tillage.

The following presents the view of Professor Chilcott[1] of the United States Department of Agriculture with regard to deep ploughing. " Perhaps one of the most common fallacies is that deep ploughing invariably and necessarily increases the water-holding capacity of the soil. Our investigations show that in many instances the receptivity of the soil is governed entirely by the physical condition of the upper 4 or 5 inches, the undisturbed sub-soil being

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[1] *Year-Book of the United States Department of Agriculture*, 1911, p. 254.

of such a nature over very considerable portions of the Great Plains that it is able to transport downward by capillarity all the moisture absorbed by the surface layer of soil as rapidly as it is accumulated in that layer. Under such circumstances there would manifestly be no increase in either the receptivity or water-holding capacity of the soil if the ploughing were deeper than 4 or 5 inches. Whether this rule will apply to any given soil can be determined only by careful observation, which should extend over a sufficient period of time to include a considerable range of climatic conditions and particularly the varying degrees of intensity and duration of rainfall." Another group of investigators[1] state: "The advocates of deep tillage and ploughing to the depth of a foot to sixteen inches argue that the deep stirring and loosening of the soil creates a greater ability to store water. At none of the Stations in the Great Plains have these claims been justified by the results of experiments."

We have at present in India a wave of deep-ploughing sentiment and the above will certainly afford food for a good deal of reflection and investigation in that connection.

Another interesting and rather unusual statement[2] from one of the experimental stations of the Great Plains area is as follows:— "Advocates of dry-farming systems based on the 'dust blanket' theory strive by maintaining a soil mulch to reduce the loss by evaporation. They reason that by stirring the surface, capillarity will cease to act in bringing up water from the lower depths to the surface. But they fail to take into consideration that because of the absence of a free water table capillarity as a force for moving water upwards ceases and is of no practical importance.[3] The apparent benefits as measured by increased moisture content attributed to the soil mulch, have more than likely been due to the fact that in maintaining the soil mulch, loss of water has been prevented

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[1] *Bulletin No. 110, North Dakota Experiment Station*, p. 172.

[2] *Ibid* p. 174.

[3] This statement is not supported by experimental evidence included in this publication: but there is abundant proof of it in data of the Office of Dry Land Agriculture, a part of which has been published by W. W. Burr of that office, in *Research Bulletin No. 5, University of Nebraska*, pp. 75-77.

by the eradication of the greatest dissipators of soil moisture—namely, *weeds*. From the standpoint of moisture conservation cultivation is beneficial when weeds are destroyed or prevented from growing. This fact should not be taken to mean that less cultivation is necessary but rather that such operations should be performed at times when weeds can be combated. If the soil checks and cracks deeply, air is allowed to circulate below the normal drying depth of the surface and cultivation then is necessary. **Otherwise the soil mulch can be disregarded.''** (The heavy type are ours.)

However that may be in other sections, the writer in his visits to the fields in Utah was indeed amazed to find that within 3 to 4 inches of the surface mulch, under a continuous, hard, hot sun, with neither rain nor dew, the soil should be found to be ideally moist for crop growth and that it should be in this condition to a depth of 6 or 8 feet. If the writer had not personally seen this, it would have been difficult of belief, so incompatible appear the dry, hot surface mulch at the top and the cool moist soil below.

Even in the Great Basin region, however, ploughing deeper than 7 to 8 inches has not had any marked effect on the yield or the water stored. In fact as a result of five years' experiments at the Nephi Sub-Station,[1] Utah, no material difference was observed in the yields obtained from the plots ploughed at different depths varying from 5 to 18 inches.

Indeed in the light of these findings, the question of deep ploughing in India deserves more than a casual and theoretical consideration. It may turn out after all that what we want most is deep intertillage rather than deep ploughing.

Speaking of the soil mulch Professor Farrell[2] has drawn attention to the fact that two factors enter in the formation of soil mulch—receptive and retentive. He has shown how in parts where wet and dry periods alternate in rapid succession, the receptive

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[1] *Bulletin No. 157. U. S. Dept. Agri. Contribution from Bureau of Plant Industry*, p. 44.

[2] *Dry-Farming*, vol. V, no. 2, p. 245. *The Annual Hand-book of Dry-Farming, 6th International Dry-Farming Congress.*

and the retentive condition of the soil mulch oppose each other. Thus the 'dust mulch' so much advocated by authors in dry-farming becomes actually a hindrance in the effective reception of the precipitation specially in heavier soils, because the fine dust mulch under a heavy rain, runs together and interferes with penetration and occasions an excessive loss by run-off. The run-off in such cases may actually exceed that from a soil which has no mulch at all. Reference has already been made to the observation that 80 per cent. of the rain was lost by surface washing in a heavy rain on a level summer fallow while under the same conditions it was observed that only 40 per cent. was lost on an adjacent stubble field.

In considering the soil mulch therefore in parts where dry and wet periods alternate as in India, both the receptivity and the retentivity of the soil condition should be borne in mind. As a result, in heavy soils it will be safer to leave the surface relatively coarse and lumpy to reduce the tendency for running together and causing a loss by run-off.

Discussions with regard to the value of a summer fallow run quite as hot as on the value of deep ploughing. Thus, results obtained in North Dakota show that while stored water may be of value in supplementing rainfall, it is unable in itself to mature a crop in Western North Dakota ; but even here it is admitted that summer tillage has a certain value as insurance against crop failure. Others[1] find it too extravagant a system. Clothier[2] states that summer fallowing by the ordinary methods has not been successful in permanently accumulating water in the soil even after a two-year fallow in Arizona.

It must not be forgotten in this connection that those who advocate summer fallowing do it for a certain set of conditions:—(1) Where the annual rainfall is too small to produce a crop every year, (2) under particular conditions of depth and uniformity of the soil. That such is the case is proved by hundreds of moisture determinations and crop results in the Great Basin. Even here

[1] *Year-Book of the U. S. Dept. of Agri.* 1911, p. 253.
[2] *Bulletin No. 70, Arizona Experiment Station*, p. 797.

when conditions of soil or rainfall are better, the summer fallow is practised only once in three years. In other places once in four years is found enough. In Kansas it is customary to do so only once in six years.

A modification of summer fallow, which owing to the poor humus content in Indian soils is likely to prove very useful, is the turning under of a green crop in the fallow year. This will not only improve the physical condition of the soil, the chemico-bacterial activities and the consequent liberation of plant food, but will also add to its water-holding capacity on account of the added humus. Experiments so far, however, tend to show that in India it does not pay to turn under huge quantities of green matter unless there is enough water available for complete decomposition of this material and its assimilation by the soil. The aim should be to turn under only as much as would be properly decomposed and assimilated. Even if it is only a slight growth that is ploughed under, it would do more good than a huge mass of loose decomposing matter intercepting the continuity of the soil and upsetting all its useful physical functions.

Choice of crops, Rotations, and Machinery.

Choice of crops. The limited amount of available water naturally requires the growth of only drought-resistant crops. Kearney and Shantz[1] describe drought-resistant plants as having the ability either to endure, to evade or to escape drought so as to produce successful crop growth. Ability to endure a drought may be due to the storage of water in the plant body or ability to become dormant. Of the cultivators' crops, the tendency to become partly dormant is shown by alfalfa and *sorghums*.

The evading of drought can be accomplished by control of transpiration or exceptional root development. Alfalfa with its deep tap root illustrates this point among the cultivated crops.

The adaptation for escaping the drought is illustrated by plants that require a very short growing period before the season of drought begins, such as the early varieties of small grains.

[1] *Year-Book of the U. S. Dept. of Agri.* 1911, p. 352.

However, the crop plants to succeed under dry-farming conditions must possess more than one of the adaptations above mentioned. Thus alfalfa has not only the ability of becoming partly dormant under adverse conditions but can also partly evade drought on account of its deeply penetrating roots. The early varieties of successful small grains have not only a shorter growing season but also are characterized by a small total leaf surface reducing transpiration. The authors mentioned above found that *sorghums* afford the best example among crop plants of a combination of adaptations for meeting drought. They are specially drought evading, and also have considerable power of endurance. In seasons when the rainfall is normal as to total quantity but very irregular in its distribution, while crops like alfalfa and *sorghums* may finally give good yields, corn and potatoes for example which have less ability to become dormant may utterly fail. Thin planting, clean cultivation, cutting and pruning and growing dwarf varieties are other means of evading a drought.

The ultimate object of farming being profitable crop production, such crops must only be grown as are reasonably secured from destruction by drought and which also when grown under the conditions of moisture supply normal to the region, can give a product that will be remunerative to the grower.

It is owing to this factor of profits that wheat is the principal dry-farm crop. Winter wheats wherever possible always give better returns. Of the spring wheats the Durums have become the most popular. In the southern section of the Great Plains Region *sorghum* is found to be the most remunerative and is already a staple crop in parts of Texas, Oaklahoma, Kansas, and New Mexico.

Alfalfa ought to prove a very useful rotation crop in dry-farm regions provided it is not too thickly sown, about 5 to 6 lb. being enough. As a rule dry-farm alfalfa yields well as a seed crop, though, if properly cared for, good hay can also be obtained. *Sorghum* is the third principal dry crop and is likely to extend in cultivation. Other crops like barley, oats, corn, are sometimes used in rotation with wheat in some parts especially in the northern Great Plains area.

A fact that was once overlooked and led to disastrous results is the thin rate of seeding to be used. A thickly sown field may look better at the start but it so depletes the moisture-supply in the soil in the preliminary stage of leaf and stalk formation that very little is left for use at the critical time of forming the grain. Thin seeding is, therefore, a very essential factor in successful crop production under dry-farming. 25 to 30 pounds of wheat seed is used to the acre in the Great Basin.

Rotation. No rotation practically exists where summer fallow is practised every year. In some others where the land is fallow once in three years wheat after the fallow and spring barley following the wheat is taken. In some cases when the soil has run down, it is put down to alfalfa for three or four years before growing wheat again.

Machinery. An average holding to make farming pay is supposed to be 160 acres with half the area in fallow every year. In addition to the necessary wagons and hand tools and four horses the following complement of machinery is recommended—a plough, disc harrow, smoothing harrow, drill seeder, harvester or header and mowing machine.

Threshing is always done on contract by travelling tackles.

Power farming is practised on a few unusually large estates, but has not yet become a general feature like power threshing.

One thing more than another which has made dry-farming profitable is the effective machinery which has enabled the farmers to cultivate and farm their lands cheaply. In Dr. Widtsoe's opinion, dry-farming more than any other system of agriculture is dependent for its success upon the use of proper implements of tillage and that if it were not for the invention of labour-saving machinery, it is doubtful whether the reclamation of the great arid and semi-arid regions would ever have been possible. The future as well as the past of dry-farming is thus intimately connected with the improvements already made and to come in farm machinery.

A review of conditions in India.

Such being the factors that control success in dry-farming in America the next point is to consider how we stand in these respects in India. If land is to be prepared efficiently so as to receive and retain the rainfall effectively, costly machinery must be used. In most cases for the present it is beyond the means of ordinary farmers to own these machines for themselves. The only way, therefore, is to use them co-operatively and the great strides that this movement is making at the present ought to make such a co-operative preparation of the soil possible where it is proved by experiment that dry-farming can be profitably pursued.

Conditions of rainfall in India are similar to those of the Great Plains region of the dry-farm section in America. Professor Chilcott describing the variableness of the season in this section says, " Within the area specified, annual precipitation at a given station may easily range during a term of years from as low as ten to as high as thirty inches. It is not an unusual occurrence to have a single torrential downpour of rain which exceeds in amount the normal precipitation for the month in which it occurs. These torrential rains frequently come with such force as to puddle the soil surface, thus making it impervious to water and resulting in the utilization of but a small percentage of the precipitation."

If one had started describing the uncertainty and variableness of rainfall in India, the description would tally word for word, with the difference that every factor mentioned is far more pronounced in India. As every one knows it is the uncertainty and variableness of the rainfall that upsets farming in India and not the smaller amount. Our similarity to the Great Plain region does not consist only in the variableness of the season but also in the fact that all our rain is received while the crops are growing, delivered in about 4 months period technically, but really in not a few days but only a few hours. Our problem thus is unquestionably more difficult to meet, not because of this fact alone, but also because the dissipating forces are very strong. The only thing that serves as a partial off-set is the large amount of our average annual rainfall and possibly our deep soils where such exist in districts of large rainfall.

While discussing the influence of soil in dry-farming, attention has already been drawn to the fact that it is a misunderstanding to suppose that only clayey soils are adapted to dry-farming. In fact as explained above loams and lighter types of soils are even preferred, where they are uniform to a depth of 8 feet or more. In fact this uniformity of character is the corner stone of the dry-farming system. It is this uniformity unhampered by hard-pan or gravel seam or a murum layer or clayey sub-soil or sticky shale, that gives free scope of movement to the water from one depth to the other. The force of capillarity is uniform throughout ; there is no hard-pan to limit the soil's storing capacity nor a pervious layer to drain off the much needed water down below beyond recovery when needed by the crop, owing to the feeble lifting power of the intervening pervious layer.

The water in such uniform soils simply travels up and down under the influence of capillarity and gravity, but never goes so deep as to be beyond the reach of plant roots. Such deep soils are not infrequent in India and must prove of great value.

It goes without saying that the yields under dry-farming methods are bound to be smaller than in others, and that a kind of insurance must always be paid in the higher cost of using dry-farming methods entailing greater cost of crop production. But dry-farming has succeeded best where a drought is anticipated every year and provision made to fight it. It will never be a success so long as the farmer indulges in the costly temptation of the higher and cheaper but uncertain yields over the admittedly smaller and costlier but certain yields under the dry-farming system.

On theoretical considerations it seems possible that such a certainty of yields can be obtained over quite a large area if dry-farming methods are carefully followed. Experiments on the spot must prove that such is the case.

When found successful, it will practically do away with the crowding in of all agricultural operations in a very small period of the year, leaving the rest unoccupied. It will make farming more evenly distributed and will consequently put a value on the now idle labour of the farmer and will give a certainty to his vocation

It is not a problem that can be solved in one or two years' time, neither is it one that can be successfully met by one cut and dried method. Different soils and climatic conditions will respond to different treatments, and consideration must be given to all these factors. In some, fallowing might be found necessary in a cycle of three or four years. In others it might become necessary every other year. In some cases fallowing with green manuring will have better effect. Some crops might do better in one section and others in others. Fortunately there is no lack of dry-farm crops or varieties in India. Consciously or unconsciously we have been dry-farming most of the time in certain districts. What is wanted is the building up of these crops to constitute a pure strain. Wheat, *juar*, cotton, lucerne, gram, linseed, all will find a place in our system. The point is to experimentally prove what is the best system for given conditions of soil and climate. If there are any means by which something definite can be evolved out of the fickle Indian monsoon they are likely to be the rigorous adaptations of dry-farming principles.

It is a problem that is ever present before the agricultural investigator, the Government and the cultivator, year in and year out. When all the countries in the world—America, Canada, Mexico, Brazil, Australia, Africa, Russia, Turkey, Palestine and even China—have lined up and gone ahead in dry-farming investigations, is it fit that we in India, who would perhaps benefit most from such an investigation, should not be in the forefront ?

ON THE MODE OF INFECTION AND PREVENTION OF THE SMUT DISEASE OF SUGARCANE.

BY

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THE smut disease of sugarcane is caused by the fungus *Ustilago Sacchari Rabenh.* and is easily recognized by the characteristic long whip-like sooty black shoot, devoid of leaves, produced from the top of the affected plant. This is often several feet in length and much curved on itself. In its earlier stages it is covered by a thin silver-white sheath, which later on ruptures and exposes a sooty black dust which consists of the spores of the fungus.

As a rule only the thin varieties like Sanna-bile and Ashy Mauritius[1] are attacked. The thick varieties—Pundya and Red Mauritius, for example—cannot, however, be regarded as altogether immune, as they unmistakably showed the disease on the Manjri Farm during the last two or three years.

Dr. E. J. Butler,[2] in his paper on the "Fungus Diseases of Sugarcane in Bengal," suggested the possibility "that the smut disease can be transmitted both through the infected sets cut from diseased plants which contain living mycelium and also through spores." The same author states further that "experiments in treating this smut are still to be carried out.....Whether it is possible by pickling the sets in copper sulphate or some of the other methods which have proved efficacious against grain smuts, to prevent spore-infection of sound sets remains to be seen."

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1 Ashy Mauritius is originally a thick variety, but on the Manjri Farm it looks more like a thin variety than a thick one.

2 Butler, E. J. *Mem., Dept. of Agri. in India, Bot. Ser.*, vol. I. no. 3, 1906.

The experiments described here were suggested by these remarks of Dr. Butler. The object in view was to ascertain how infection usually took place in the field in the case of smut in sugarcane and to test the efficacy of treatment of sets with copper sulphate previous to planting.

The experiments recorded below were carried out during the last three years on the Government Sugarcane Experimentel Station at Manjri near Poona, where smut has been appearing sporadically year after year, particularly on some of the thin varieties. The writer is indebted to Mr. Mahajan, Superintendent of Manjri farm and to Messrs. Padhye and Sane, Graduate Assistants on the same farm, for looking after the experimental plots and much help during the progress of the experiments.

Experiment No. 1.

1912–1913.

Method. Careful search was made for stools entirely free from smut in the Ashy Mauritius plot and sixty sets fit for planting were selected from these. Another lot of sixty sets was cut from canes which had distinctly shown the smut. The healthy and diseased sets were further divided into two lots of thirty sets each and one half were steeped in copper sulphate solution of 2 per cent. strength for fifteen minutes and the other half was left untreated. The sets were then planted in four plots as follows :—

Plot No. I	...	Diseased sets 30, steeped.
Plot No. II	...	Diseased sets 30, unsteeped.
Plot No. III	...	Healthy sets 30, steeped.
Plot No. IV	...	Healthy sets 30, unsteeped.

The sets were planted on the 13th of Decembar 1912. The plots were chosen in a part of the farm far removed from any standing sugarcane. The soil was virgin soil[1] broken up for the first time for this experiment.

Observations. The germination was uniform in all the plots except No. IV, where only a few shoots came up.

[1] This remark does not hold good for the other experiments that follow.

The first case of smut observed was on 13th March 1913 and it occurred in plot No. I.

In May 1913, smut was found in all the plots except in No. III.

No. III remained smut-free till November 1913, when three smutted shoots were observed in it.

It was not possible to make an exact count of the smutted shoots in all the plots, yet it was observed that No. II suffered the most and No. III remained smut-free the longest and suffered the least.

Remarks. The results of the experiment pointed to the following conclusions :—

(1) Infection may be carried in diseased sets, as indicated by the behaviour of plot No. I.

(2) Steeping sets in copper sulphate solution is not, by itself, sufficient to prevent smut; indicated by the plots Nos. I and III.

The appearance of smut in plot No. IV which had sets from healthy canes in it may be due either to infection by spores adherent to the sets or dormant mycelium in the sets resulting from direct aerial infection by wind-borne spores on parent canes, though the latter showed no external signs of it.

EXPERIMENT No. 2.

1914-1915.

The experiment of 1913-1914 was repeated, using a hundred sets to each of the four plots as in the following table :—

Plot No.	Treatment	Date of planting	Germination on 1-4-14	First appearance of smut on	No. of smutted shoots on 13-2-15
I	Healthy sets, steeped in copper sulphate 2 per cent. strength for fifteen minutes.	27-2-14	17 shoots	21-5-14	3
II	Healthy sets, unsteeped ...	27-2-14	159 ,,	29-5-14	122
III	Diseased sets, steeped as above	27-2-14	2 ,,	21-5-14	2
IV	Diseased sets, unsteeped ...	27-2-14	109 ,,	21-5-14	228

Remarks. Steeping was found to retard germination seriously and had no effect in preventing smut. A regular count of the number of healthy shoots at the end of the experiment was found impracticable in this as in the other experiments recorded here owing to excessive tillering; hence the proportion of smutted to healthy shoots could not be ascertained. Yet the figures for smutted shoots give a clear indication that smut appears to the greatest extent in those plots which had sets from diseased canes planted in them. It has to be remembered in interpreting these figures that the germination in the plots Nos. II and IV was much better than that in the corresponding plots Nos. I and III. When corresponding plots only are compared, the infective power of diseased sets becomes quite apparent. The appearance of smut in plots with healthy sets in them again suggests infection by spores adherent to the sets or by dormant mycelium in apparently healthy canes resulting from direct aerial spore-infection.

Experiment No. 3.

1915–1916.

The experiment of 1913-1914 was repeated using a hundred eyes for each plot and using two strengths of copper sulphate for steeping. There were, therefore, six plots in this experiment as under :—

Plot No.	Treatment	Date of planting	Germination on 13-3-15	First appearance of smut on	No. of smutted shoots on		Total
					31-8-15	12-2-16	
I	Healthy sets, steeped in 2 per cent. $CuSO_4$.	13-2-15	7 shoots	?	Nil	5	5
II	Healthy sets, steeped in 1 per cent. $CuSO_4$.	13-2-15	14 „	19-5-15	„	Nil	0
III	Healthy sets, unsteeped ..	13-2-15	48 „	19-5-15	1	3	4
IV	Diseased sets, steeped in 2 per cent. $CuSO_4$.	13-2-15	3 „	21-4-15	1	0	1
V	Diseased sets, steeped in 1 per cent. $CuSO_4$.	13-2-15	3 „	15-4-15	6	121	127
VI	Diseased sets, unsteeped ..	13-2-15	13 „	1-4-15	15	77	92

Remarks. These results confirm generally those of the two previous experiments. They indicate that the disease is most surely conveyed through the use of diseased sets. Steeping is again seen to be ineffective in checking smut and moreover affects germination seriously. Only three of the diseased sets treated with 2 per cent. copper sulphate solution came up and one of them showed the disease. Plot No. III with healthy sets in it has practically remained healthy without steeping.

EXPERIMENT No. 4.

1915–1916.

Objects. To determine if smut spores adhering to the surface of sets are able to carry the disease and also to observe the effect of copper sulphate solution on adherent spores.

Method. Smut spores were smeared on to the surface of 25 sets planted in each of the three lines labelled II, III and IV. Sets for Nos. II and III were steeped in 1 per cent. copper sulphate solution for ten minutes. No. I was left untreated in any way as a control. All sets were selected from smut-free canes (Sanna-bile variety).

Plot No.	Treatment	Date of planting	Germination on 8-4-15	First appearance of smut on	No. of smutted shoots on		TOTAL
					31-8-15	12-2-16	
1	Control	13-3-15	53 shoots	2-6-15	1	1	2
II	Covered with spores; steeped.	13-3-15	28 ,,	12-6-15	1	25	26
III	Ditto	13-3-15	37 ,,	16-6-15	5	ver 500	Over 500
IV	Covered with spores; unsteeped.	13-3-15	58 ,,	16-6-15	1	Practically every shoot was smutted	

Remarks. There was no indication in the earlier stages of the experiment that adherent spores carry on the disease but towards the end[1] the infective power of adherent spores was quite clearly shown, practically every shoot showing the disease in plots III and IV and many in plot II. Steeping is again seen

[1] This result is in agreement with that obtained in Java as quoted by Dr. Butler (*loc. cit.*).

to have no value in the treatment of sugarcane smut, especially as it has again affected the germination of the eyes. The use of sets from healthy canes in the control plot gave a crop practically free from disease without steeping.

Experiment No. 5.

1914.

This was designed to verify the deleterious effects of the copper sulphate treatment on the germination of sugarcane sets indicated in the other experiments.

Method. Sugarcane sets were steeped for different lengths of time and in different strengths of copper sulphate solutions (2 per cent. for 30 and 10 minutes; and 1 per cent. for 30 and 10 minutes). Sets with 100 eyes counted were used for each item and were planted on 22nd August 1914.

Observations on 16th September 1914 :—

Treatment	Number of shoots come up
2 % for 30 minutes	0
2 % ,, 10 ,, ...	1
1 % ,, 30 ,, ...	4
1 % ,, 10 ,, ...	9
Control—unsteeped	26

Remarks. Here, again, the deleterious effect of steeping is noticeable, though the germination even in the control plot was rather poor.

Experiment No. 6.

1915.

This was carried out in the Seed-testing Laboratory at the Poona Agricultural College, to place beyond doubt the result of Experiment No. 5.

Method. Sets having 20 "eyes" in all were steeped in a solution of copper sulphate of 1 per cent. strength for ten minutes and another lot having 12 "eyes" on them were left untreated as control. These were germinated on moist sand. The experiment was started on 15th March 1915.

Results on the 26th March 1915 :—

1. Untreated ... All buds germinated; shoots vigorous, about eight inches, vigorous growth of adventitious roots.
2. Treated ... Only three buds showing some life; hardly any root growth.

A photograph of this experiment taken on the 27th March is given opposite (Plate XX).

Remarks. This experiment leaves no doubt as to the injurious effect on sugarcane sets of steeping in copper sulphate solution.

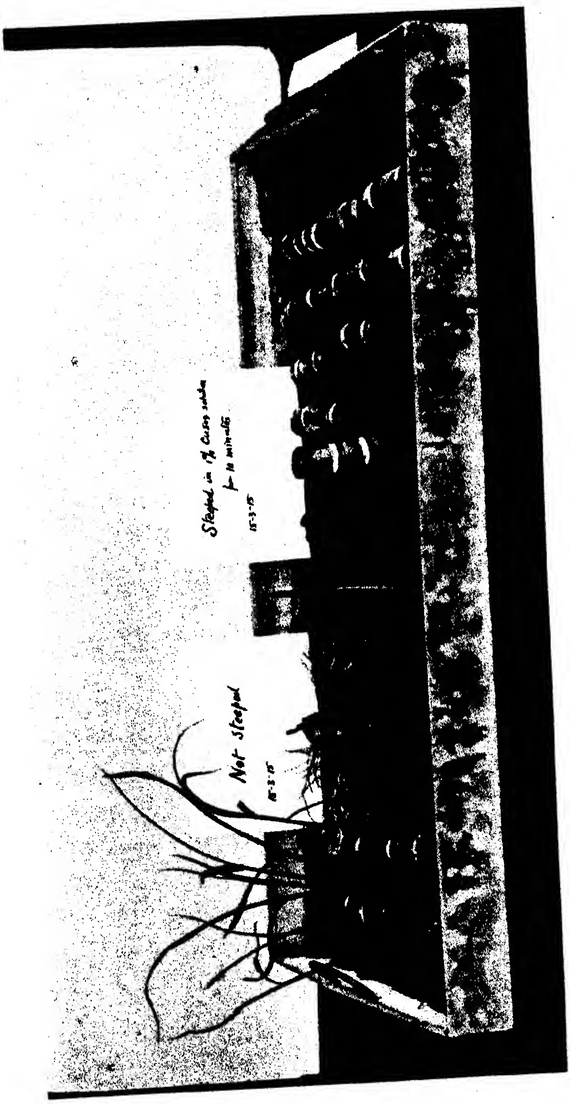
General conclusions.

The above experiments indicate clearly that the surest way of getting smut in a crop of sugarcane is by the use of sets from diseased canes. The cultivators, as a rule, do avoid obviously diseased canes for planting purposes and this explains probably why the disease has existed so far only in the sporadic stage. As an additional precaution, however, it may be suggested that not only obviously diseased canes but also the whole of the stools which show the disease on one or more shoots should be avoided for seed purposes, as they are likely to contain the fungus though there may be no external signs of it.

That the source of infection when diseased sets are used for planting is the mycelium of the fungus in the tissues of the sets is indicated by the evidence obtained by microscopic examination of the tissues of affected canes. Even in hand sections, the mycelium of the fungus has been clearly made out in the sixth node behind the apex and it is possible it could be made out still further below by more elaborate histological methods. That the fungus can get into the buds and side shoots of an affected cane is also shown by the fact that side shoots of not more than six inches in length from quite near the base of an affected cane already show smut occasionally and further by the fact that microscopic examination in a few cases revealed the presence of the fungus in the tissues of the dormant buds of an affected cane.

Smut generally appears early in the life of the crop, in three to five months from the planting, when the source of infection is diseased sets.

PLATE XX.



Effect of steeping in copper sulphate solution on germination of sugarcane sets.
(Photograph taken on 27-3-15.)

Infection by spores adhering to sets takes place, but the attack in this case does not become obvious till the crop approaches maturity.

Aerial infection of shoots by spores and the formation of a dormant mycelium in them is probable, though the above experiments give no direct proof of this. Infection by spores lying in the soil also possibly occurs. But these questions can only be settled by further study.

Steeping in copper sulphate solutions is useless and worse still, it affects injuriously the germination of sets.

The practical method of dealing with the disease suggested from the experiments is to destroy diseased canes whenever noticed and to avoid diseased stools for seed purposes. This alone may prevent the disease from going beyond the sporadic stage in which it exists at present.

THE TUBE-WELL AND ITS IRRIGATION POSSIBILITIES.*

BY

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THE climatic conditions prevailing in India, getting as we do, practically all our rainfall condensed into about 3 or 4 months of the year, with the remaining 8 or 9 months almost rainless, compel us to seek artificial means of watering the growing crops during the long dry period. We, therefore, rightly look upon the irrigation problem as an important one, and any methods of improvement in this direction will, I am sure, be welcomed by all who are in any way connected with the agricultural industry. We all of us then, in this meeting, start with a lively interest in the subject under discussion.

The tube-well is of many different sorts, but all have the same object in view, that of tapping the deeper and stronger springs of water. The kind we are mostly concerned with is of the strainer tube type, this being the most suitable for catching the percolation water in the deep sands underlying the whole Gangetic plain of this province. The ordinary pakka well is seldom sunk more than 30 feet beneath water level, and more often is only from 10 to 20 feet, so it does not always strike the copious springs of water in the lower strata. A hole is of course, frequently bored through the clay bed upon which a well-cylinder rests, thus getting the water from the first sand or water-bearing stratum beneath. In some cases, with exceptionally good conditions, such as a thick and strong clay bed above a thick stratum of coarse water-bearing sand, both being beneath subsoil water level, a very good yield of water

* A paper read at the United Provinces Co-operative Conference, held at Lucknow in February 1916.

is got, enabling a power pump to be used on the well, lifting as much as 8 or 10 *charsas*. Such places are exceptional though, and the great majority of wells in this province are giving two *charsas* of water or less. If at least a six *charsa* yield cannot be got from a well it does not pay to put in a pumping engine, the increased profit from the small area irrigated being insufficient to repay the initial cost of the plant and the running costs. This rule at once places most of the pakka wells of the provinces outside the useful limit for power pumps, unless they can be so improved as to cause them to yield a much larger quantity of water. We will consider later on in this paper the question of improvement of existing wells.

To return to the tube well. The difference then between it and the ordinary pakka well is that the former goes deeper, through successive beds of water-bearing sand, gathering the water from each bed, whilst the latter is shallow and draws its water from one sand bed only. The tube-well is generally sunk from 100 to 400 feet deep beneath ground level in this province. This may sound deep in comparison with the depth of ordinary pakka wells, but in reality it is not at all deep when compared with similar tubular wells in other parts of the world. In Australia, for instance, a lot of the borings are obliged to be from 2,000 to 4,000 feet deep in order to tap the underlying water, the strata above being all impervious to water and so being non-water bearing.

Although in this province we get, as I previously stated, practically all our rainfall in three months of the year, yet we are especially well favoured by nature with an inexhaustible supply of underground water, generally at a very moderate depth beneath ground level, to draw from to tide us over the dry nine months until the next rainy season. This underground water is stored up in the sand beds which extend to depths of thousands of feet beneath us, every cubic foot of sand containing roughly about one-third of a cubic foot of water. It will thus be seen what an immense supply of subterranean water we possess. It is not at all likely, so great is our supply reservoir, that any system of irrigation using more numerous and larger wells, can start to make an impression on our supply or even affect to any appreciable extent the subsoil

water-level. As long as our rainfall remains what it is, an average of over 40 inches a year for the province, our underground reservoir will be replenished annually and we need not fear drawing upon it to any extent necessary for irrigation. In a 40-inch rainfall something like 14 inches of water percolates through the upper strata down into our great natural reservoir and this is over the whole of the province. We lift for irrigation 6 or 8 inches depth of water for a *rabi* season and this only over about half the area of the province, say equivalent to 4 inches over the whole area. We thus see that far more water is annually put into our reservoir than we are ever likely to take out. It looks from these figures and statements, that the subsoil water-level would be constantly rising until we might suffer from a water-logged soil unsuitable for crops, but nature again comes to our assistance and provides a safety valve to let off the excess underground water, in the shape of numerous low valleys and river beds which act as great natural drains. Far more underground water drains off thus than we lift or ever will lift with extended systems of wells, for irrigation of crops.

Granting then our immense supply of water underground, we ought to study the question carefully as to whether we are making full use of this very excellent provision of nature, and when we compare the fine crops of canal-irrigated tracts with the poorer ones, and sometimes in the absence of winter rains the stunted ones, of some parts outside canal influence we are bound to confess, I am sure, that we are not doing all we should be in the way of water lifting. It is an extremely important matter, as only about one-fifth of the province is canal irrigated, leaving the other four-fifths to be watered by lifting from wells, *jhils* and *nadis*. There is no real reason why the crops of this province should not be as good and as paying in one part as another, whether within or without the area commanded by canals, were we to take full advantage of our underground store of water and employ modern methods of lifting it on to the land.

Areas irrigated from *jhils* and *nadis* are small in comparison with those watered from wells, so in this paper we will only consider the latter. What then is the best way of tackling the problem of

irrigation from wells ? At present with the existing wells small areas of 8 to 15 bighas are watered round each good well, and in order to irrigate more extended areas we should either want a very large increase in the number of pakka wells or should require each existing well to give much more water. The tube-well comes in here as the great agent for well improvement where wells are suitable for it. By sinking a big tube-well in a good existing pakka well, it can be turned at once from a two *charsa* well into a 15 or 20 *charsa* one. The well should have a depth of water in it of at least 25 feet, to be suitable for taking tube-well, so a great many wells cannot be so treated. However, the tube-well is just as useful in yield, and costs no more, when sunk by itself as if it is sunk in an existing well. No matter how difficult the subsoil conditions are, the tube-well, if sunk, is master of the situation. In some places what is called a " mota " a thick clay bed is not found at all at reasonable depths, nothing but sand exists to rest the well-cylinder in, for an ordinary pakka well. Such wells in sand always cause trouble. The sand flows into the well, which requires frequent cleaning out, and often the brick well-cylinder sinks and cracks. At the best not more than one *charsa* of water can be got from such a well. A situation like this is especially favourable for a tube-well, and success can be absolutely relied on with it.

Again in other parts the clay beds are so thick and deep that a pakka well cannot get deep enough, at reasonable cost, to pierce them and strike the deeper water-bearing sands beneath, even though a hole be bored in the bottom of well. Here too the tube-well will succeed, as if need be, it can be carried down 200 or 300 feet until the coarse water-bearing sand is met with.

Regarding the cost of a tube-well, it varies according to the depth it has to be sunk. The boring must be continued until sufficient water-bearing sand is struck to give the requisite quantity of water. The cost is generally from Rs. 3,500 to Rs. 5,000. This may sound a high price when compared with that of a good pakka well costing perhaps Rs. 1,000, but compare the yield of water and it will then be seen that the tube-well is cheap. About 8 or 10 pakka wells at say Rs. 1,000 each would have to be sunk in order

to get as much water and irrigate as much land as one tube-well; so you get for Rs. 4,000 in tube-wells what you would have to pay Rs. 8,000 for in pakka wells. Further than this the price I mention for a tube-well includes a good engine and pump for lifting the water, and the use of a power pump will save the strain on bullocks at lifting water by *charsa.* The engine also can be used for other purposes besides pumping. For expressing the juice from the sugarcane a mill can be used, run from the engine, giving at least 10 times the outturn of the ordinary bullock mill. Or a small flour mill can be run and be made a source of profit. The area irrigated from one tube-well is about 8 or 10 pakka bighas a day or a total of 200 to 250 bighas in the season. The cost of the irrigation will of course vary with the depth from which the water has to be lifted. Taking 30 feet as the average depth from ground level to water level, at this depth the irrigation will cost about R. 1 per pakka bigha for each watering. Giving a *rabi* crop three good waterings during the *fasl* would thus cost a total of Rs. 3 per pakka bigha for the season, a cost which would be recovered several times over by increased crops due to proper irrigation.

Granted then that the tube-well is useful, and not costly for its output and utility, what is there to prevent its more extensive use? The main drawback is the very small holdings of the cultivators. A man cannot afford to put in a tube-well costing, say Rs. 4,000 which will irrigate easily 250 pakka bighas of land when he has only a few bighas of land himself to cultivate. The remedy for this is obviously co-operation, a number of men joining together to own a tube-well, and all getting water from the one tube-well in turn. This Conference is especially a co-operative one, and I would like to impress upon those present the very useful work that can be done by co-operative banks in sinking tube-wells. Success has hitherto been such that risk of failure may be regarded as negligible. There has been no single case of failure at all with our work in this province.

I am quite sure a tube-well is a sound investment and it is a form of well which I am certain has a big future before it in this province, the conditions being so eminently suitable.

AGRICULTURAL SAYINGS OF THE UNITED PROVINCES.

BY

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COLD weather touring is a great institution in these provinces and the officer who camps with his eyes and ears open will see and hear for himself in what a world of elemental hopes and fears the majority of the ryots move and have their being. They have the experience of untold centuries behind them and where this experience relates to agriculture they have for mnemonic reasons, set it to rhyme. These rough and ready rhymes escape their lips from time to time and when they hear you support your scientific explanations with an old world rhyme tried wisdom is imparted to it and it is accepted as gospel truth. On many a wintry evening have the old men of the village gathered round the camp of the present writer and talked to him about agricultural prospects. Agricultural rhymes have then accidentally fallen from their lips. The writer has collected these and others from *shagunbichar* books and privately owned manuscripts prescribing appropriate days for different agricultural operations. One Bhaddar Rishi is the general spokesman. Sometimes it is wisdom *à la Sahadeo* (the astrologer Pandava); sometimes it is the devoted wife nagging her patient husband to do something or forbear from doing something else.

In order that one may profit by this "wisdom"—full of empirical generalizations or occult pronouncements—a list of Indian Nakshatras or Lunar Mansions is given below with the names of the twelve signs of the Zodiac and it has been shown for Samwat 1972-73 for how many days each of these nakshatras lasted. The

months given are Indian months but their English equivalents which vary will be easily available. There are 12 rashis (signs of Zodiac) which are divided into 27 divisions called nakshatras, each rashi containing $2\frac{1}{4}$ nakshatras.

Most of the sayings turn on rain—its normal fall or defect or excess. The first monsoon nakshatra is Mrigshar and commences from the Badi 10th of Jeth, 1972.

Indian Nakshatras or Lunar Mansions.

Constellation	Date on which the constellation begins	Sign of Zodiac	Date on which the sun enters the sign of Zodiac
* (5) Mrigshar (½) ..	Jeth Badi 10, 1972 ...	Mithun or Gemini.	June 14th.
* (6) Ardra	Jeth Sudi 9 ...		
* (7) Punarvas (¾) ..	Asarh Badi 9		
Do. (¼) ...	......	Kark or Cancer.	July 16th.
* (8) Pushya	Asharh Sudi 7 ...		
* (9) Ashlesha	Sawan Badi 8 ...		
* (10) Magha	Sawan Sudi 7 ...	Sinh or Leo.	August 17th.
* (11) Purva Phalguni ...	Bhadon Badi 6 ...		
* (12) Uttra Phalguni (¼) ...	Bhadon Sudi 4 ...		
Do. (¾) ...	......	Kanya or Virgo.	September 17th.
* (13) Hasta *alias* Hathia ...	Kuar Badi 4 ..		
* (14) Chitra (½) ...	Kuar Sudi 2 ...		
Do. (½)	......	Tula or Libra.	October 17th.
* (15) Swati	Katik Badi 2 ...		
(16) Vishakha (¾) ...	Katik Badi 14 ..		
Do. (¼) ...	......	Vrishchak or Scorpio.	November 16th.
(17) Anuradha	Katik Sudi 13 ...		
(18) Jyeshtha	Aghan Badi 10 ...		
(19) Mul	Aghan Sudi 9 ...	Dhan or Sagittarius.	December 15th.
(20) Purva Asharh ...	Pus Badi 7 ...		
(21) Uttra Asharh (¼) ...	Pus Sudi 6 ...		
Do. (¾) ..	......	Makar or Capricorn.	January 14th.
(22) Shrawan	Magh Badi 3 ...		
(23) Dhanishta (½) ...	Magh Sudi 3 ...		
Do. (½) ...	......	Kumbh or Aquarius.	February 12th.
(24) Shatatarka ...	Magh Sudi 15 ..		
(25) Purva Bhadrapad (¾) ...	Phagun Badi 14 ..		
Do. (¼) ..	......	Min or Pisces.	March 13th.
(26) Uttra Bhadrapad ...	Phagun Sudi 12 ...		
(27) Revti	Chait Badi 12 ...		
(1) Ashwini	Chait Sudi 9, 1973 ...	Mesh or Aries.	April 12th.
(2) Bharni	Bysakh Badi 9 ...		
(3) Krittika (¼) ...	Bysakh Sudi 8 ...		
Do. (¾) ...	......	Vrishabh or Taurus.	May 13th.
(4) Rohini	Jeth Badi 8 ...		
(5) Mrigshar (½) ...	Jeth Sudi 6 ...		

* Rain nakshatras.

N. B.—The number within the brackets indicates the chronological order of nakshatras.

The moon in the Puranas is represented as courting the 27 daughters of Daksha Prajapati for 14 days each. These nakshatras are the wives of the moon. It is also believed that they represent the ethereal bodies of pious persons after death and therefore they are expected to influence the affairs of men here below. The moon is the lord of aushadhis or plants and hence his journeys in the firmament are watched with special interest by the agriculturists.

The seven days of the week are presided over by the following planets :—

Sunday	... Sun	... Surya.
Monday	... Moon	... Chandra.
Tuesday	... Mars	.. Mangal.
Wednesday	... Mercury	.. Budha.
Thursday	... Jupiter	... Brihaspati.
Friday	... Venus	... Shukra.
Saturday	... Saturn	... Shanishchara.

For the sake of easy reference these sayings have been abstracted here under three main heads.

(1) Rain prognostications.

(2) Agricultural operations, crop diseases, etc.

(3) General.

1. Rain Prognostications.

(a) *Interdependence between weather conditions in winter and summer on the one hand and rainy weather on the other.*

If on Katik Sudi 11th clouds and lightning are seen in the sky then there will be good rain in Asharh.

The appearance of clouds and lightning on Katik Sudi 15th with Krittika as the nakshatra foretells four months of good rainfall.

Katik Amawasya falling on Saturday or Sunday or Thursday in the Swati nakshatra is an omen of approaching famine.

Rain on the 8th day of Aghan is a good omen indicating copious rainfall during the whole of Sawan.

If the 7th of Pus goes without rain then during the Ardra nakshatra the sky and the earth will be one with rain.

If the Pus Badi 7th is without clouds or rain Sawan Sudi Punam will be a rainy day.

Lightning seen on the 10th of Pus is a happy sign of coming rain during the whole of Bhadon.

If it rains on the 10th of Pus Badi it is predicted that there will be a good rainy season.

If clouds are seen on all sides on the 13th of Pus Badi then Sawany Punam will be rainy.

If all the four directions are full of wind on Pus Amawasya, you must thatch your cottage well there will be plenty of rainfall.

The price of grain will be twice, thrice or four times dearer according as Pus Amawasya falls on Saturday, Sunday or Tuesday; if it falls on Monday, Friday or Thursday every house will be resonant with dulcet strains. (There will be plenty of grain.)

If on Magh Pariwa (bright half) clouds are seen on the horizon and the wind is blowing then Til (*Sesamum indicum*) and Sarson (*Brassica campestris*) will become dear.

Thunder and lightning on Magh Sudi 3rd is a sure sign that barley and gram seeds will be dear. If clouds are seen or if it rains on the 4th then *pan* and cocoanut will be dear.

Thunder on the Magh Sudi 7th, Pus Sudi 5th and the 10th of Aghan indicates that there will be four months of good rainfall.

The gentle wife speaks to the husband :—"If Magh Badi 7th is cloudy and lightning be seen, don't be moody, there will be good rainfall." (This the present writer thinks refers to winter rains or Mahawat and not to the good monsoon rains).

If the sky is of emerald green on Magh Purnmasi there will be seasonable rainfall. One female friend says to another "if no dew is seen on that day grain will be dear."

It is predicted from bright and clear sky in the month of Magh with Jyestha as nakshat a that all the seven staple kharif crops will be produced.

[The seven Kharif crops are :—

Kuri (early rice).
Kakuni (*Setaria italica*).
Mandua (*Elusine coracana*).
Sama (*Panicum frumentaceum*).
Makai (*Zea Mays*).
Kodon (*Paspalum scrobiculatum*).
Dhan (*Oryza sativa*)]

If on Phagun Sudi 2nd there be neither cloud nor lightning it will rain well in Sawan and Bhadon and you will enjoy Tij (Kajri Tij in Bhadon is a gala day for women).

Cattle suffer if Phagun Amavas falls on Tuesday.

If Phagun has 5 Tuesdays and Pus 5 Saturdays then alas for you, do not even sow your seeds.

If it is blowing from the west on the Holi day the whole earth will blossom forth; if from the east then the rainfall will be erratic, if from the south all the seven grasses will grow seasonably; if from the north there is sure to be good rain; if the wind is blowing from all the four sides then the ryots will suffer.

If there is severe dust storm (*rak* or ashes) on the 8th of Chait and if the 9th is wet and lightning appears there will be severe famine. The appearance of clouds and lightning on the 10th will be followed by failure of rain; but if the 10th is rainless the monsoon rains will be plentiful.

If seeds are wetted in Chait, and the petals of the beautiful *Butea frondosa* (Dhak) are washed in Bysakh and the sun shines at its hottest in Jeth, they forecast good rainfall.

Whatever be the length in Gharis of Chait Amawasya that will be the measure of the sale of unhusked rice in Katik.

If Revti is wet there will be no rains.

If Ashwini is wet there will be deficiency of rain towards the end of the season.

If on the 1st of Bysakh there are clouds and lightning then you can get very little value in exchange for 20 Jaipuris (old Asharfis).

Bysakh 3rd falling on Thursday augurs well for crops.

Wet Bharni is a bad sign, it will destroy even grasses.

If on the 5th the wind is blowing from the north then Bhadon will be a dry month. If no thunder is heard on the 6th then cotton will be dear. If the 7th ends cloudless there will be no rain on earth and no hope will be left. Ghee and oil will be twice as dear if the 8th falls on

Monday. If on the 7th there are clouds and rain there will be much rain in Asharh. If the 7th sees lightning, clouds and dewy precipitation, then all the four months will rain well. If the 7th is cloudless and 8th cloudy, Asharh (the principal rain month) will be dusty. Even big lakes will dry up if the 9th is cloudless and there will be no rain. If there is a Mandal or watery halo round the moon on the 9th move away your cottage, don't trust.

Wet Krittika is a precursor of plentiful fall at the end.

If Krittika rains grain will be dear, if Mrigshar rains then there will be bumper crops but if Rohini weeps then direst famine will follow.

If Krittika is dry and Ardra does not rain a drop Bhaddari is croaking and declares "you know very well that havoc will be wrought by famine." This is just the time for sowing Kharif crops and unless the means of irrigation are at hand absence of rain at that time is fatal.

The Moon has 27 companions but if only Krittika sprinkles the earth, everything is all right. If there be no wind during Mrigshar and Rohini constellations, if Jyeshtha does not bake (people) all round, then the fair lady (Gouri) will have to stay out on roads picking ballast stone.

Rohini nakshatra falling on Badi 10th prognosticates that there will be little rain and little grain; if that day is cloudy and it thunders "you, dear, go to Malwa" says the lady "and I to Gujerat." (Malwa in Central India and Gujerat in Western India are in popular imagination proof against famines.)

For winter rains it is said that if clouds come on Friday and stay on on Saturday then Bhaddar Rishi declares infallibly that they will not go away without raining.

It is not easy to say what the Bay or the S. W. Monsoon Current has to do with the N. W. Current well established in Upper India. But one has to live and learn and ultimately some connection will be established between the monsoon and winter rainfall.

(b) Rain during the four months of rainfall and its effects on crops.

If Jeth Parewa is hot and the 2nd thunders there is no doubt that the year will be a good one.

If Jeth Badi 10th falls on Saturday there will be no water on the earth.

Famine will follow if it rains on Jeth Sudi 3rd and the constellation happens to be Ardra.

If Rohini is wet and Ardra is windy then sell off your bullocks, there will be no profits in cultivation.

If Ardra is not rainy and Mrigshar is without wind Bhaddari declares that there will not be a drop of rain.

If the beginning of Ardra is rainy and Hast is wet at its tail then whatever tax the king may exact from the tenants the cultivating householders will be happy to pay. [The reason is simple. Early Ardra rains are required for rice and tail Hast rains for maturing kharif crops and preparing fields for rabi.]

East wind blowing in Jeth is a precursor of dust storms in Sawan.

If the month of Magh is hot while Jeth is cold and if tanks are filled up by the first rains then the poet Ghagh declares "Better be an ascetic (times will be hard for agriculturists while the ascetic will get his bread anyhow) because Dhobis will have to wash clothes in water drawn from the wells (rivers and tanks will be dry).

If Asharh Badi 5th is cloudless the dear one must go to Malwa to beg for bread.

The Bhaddar 9th (Asharh Badi 9th) falling on a Saturday is such a bad omen of impending famine that not a soul will outlive that year.

The Asharhi Punam has thundered and all the seven kharif crops will mature. If even the tip of the temple banner is wetted that day by rain there will be good times all round.

If the wind is coming from north-east on Asharhi Punam then, oh cultivator, sow your crops on uplands. (There will be plenty of water to inundate low cultivation.)

If the moon rises cloudless on Asharh Punam, you dearest go to Malwa, there will be acute distress here.

The wind blowing on the evening of Asharhi Punam in the middle of the sky or from the east, north or north-east is good. That from south-east, south-west or north-west is very bad.

The astrologer declares "Why are you cast down? Asharhi Punam has thundered and all the seven kharif crops will grow."

If Chitra, Swati and Vishakha rain in Asharh then husbands must go to another country, oh friend, for there will be a very severe famine.

If Pushya and Punarvas did not fill the tanks then expect rain next Asharh.

If the sun rises cloud-covered on Sawan Badi 5th, then move off your hut from the bank of the river.

If on Sawan Badi 5th it is blowing, then there will be a famine and birds in anticipation migrate to other countries.

If on the midnight of Sawan Sudi 7th there is thunder, then you dearest go to Malwa, I shall go to Gujerat.

If Chitra, Swati and Vishakha of Sawan do not rain down, garner grain; it will be worth twice as much.

Just as a child is not satisfied till the mother has served up the food so the soil is never satiated unless it rains in Magha. The Uttra has given her answer (in the negative) and Magha kept her maw shut, times were bad and Chitra gave reply and the situation was saved. (This is for rabi sowings.)

He who says that there will be rain in Magha, why he will see fruits on all plants.

Magha is proclaiming at every field boundary her influence and big and small, all rice stalks bear ears.

If on the Amawas of Bhadon a rainbow is seen in the west, there is the cry of 'alas.'

The east wind blowing in Bhadon will make rivers happy and boatmen ply their trade.

If east winds blow during Purva nakshatra, then even in dry river channels you will ply boats.

It is bad for Purva to be rainy.

It is said "He who says that Purva will rain down all the crops will be eaten by worms."

If it rains well in Uttra there will be such a bumper crop that even dogs will not eat the superfluous outturn. [In the western districts it is not necessary to have much rain after Uttra. Kharif crops have already matured and rabi soil is cooled down. However where there is transplanted rice Hast rains are wanted.]

Oh rice—you get hands and feet in Hast, in Chitra you get flowers and when Swati is coming on, you are spreading like a flowing robe. If Magha rains well, nothing more is desired. If not then you might wring your hands.

If Hast is rainy then wheat will grow up to the chest. [Hast rains cool the soil and if the moisture is well conserved by good tillage and producing a mulch at the top wheat will grow even without much subsequent irrigation.]

The elephant (play on the word Hast) has wagged his tail and the Jowari crop has been ripened without any more ado. (This especially refers to parts where September rains are most prized for maturing the kharif crops and cooling the ground for winter sowings.)

If it rains in Hast three crops prosper, Rice (Shali), Sugarcane and Urid (*Phaseolus radiatus*). If it rains hard in Hast three crops are ruined—Til, Kodon and Kapas.

If it rains in Chait three crops are spoilt, mothi, pulse (Urid), and sugarcane.

If there is rain in Swati and Vishakha neither will there be spinning nor will the music of cotton carding be heard.

A small fall in Swati (not a heavy and continuous downpour, otherwise cotton and dry kharifs will be ruined) is so beneficent that Kurmis (cultivators) will put on golden bangles.

If it rains in the middle of Pus the wheat plant will yield half its weight of grain and half its weight of straw. It will be a splendid crop.

Without Tula (sun entering Libra) rice ears will not appear.

If the eastern wind blows without ceasing and the widow puts on ornaments, as sure as anything, there will be rain and she will lead people astray.

Thunder in the south-west promises an early rainfall.

Rainfall will be plentiful if there is lightning towards Kampilya. (This proverb is of Etawah District.)

Partridge-coloured clouds with collyrium-like streaks on them indicate that there will be good rainfall.

If gusts of wind come like a hopping partridge then Bhaddari declares there will be good rainfall.

Good rainfall is also predicted if water gets warm by keeping, birds wallow in dust, and if ants migrate with their eggs.

If the moon is cloudy and the day is hot with sun and the eve bright with stars believe them as sure signs of famine.

If clouds start coming on Friday and bank upon Saturday there will surely be rain.

Crows cawing at night and jackals howling by day prognosticate that there will certainly be famine.

Rains when cotton is nearly ripe ruin the crop.

If the wind blows properly from south-west then you will get plenty of water at home. [This south-west wind is also called Bamura and Banda.]

If clouds overtake clouds on the horizon then Bhaddari declares that rain is imminent.

The howling of jackals during the day and the flowering of *kans* weed give no hope of rain. (*Kans* is flooded out and killed by good rainfall before it flowers.)

The Moharram which is associated in popular mind with burying of the old and the resurrection of fresh life has interwoven its importance into the lives of cultivators, be they Hindus or Musalmans, and therefore the fall of the 3rd of Moharram on any particular day of the week is carefully watched to draw omens from.

If the 3rd falls on Sunday, then there will be good rainfall, grain cheap and bumper crop of sarson (*Brassica campestris*). Trees will bear many fruits, wheat will be good, sesamum and grass plentiful and milch animals will prosper. Only cotton will be poor. But if the 3rd falls on Monday there will be half the normal rainfall. Grain will, however, be cheap, sesamum and cotton good and sugarcane plentiful. If it falls on Tuesday it will bring on unseasonable rainfall and famine. Fruits will be blown off unripe. Sesamum, sugarcane and cotton will be scarce. Servants will leave their masters and parents their children. Locusts will come. If the 3rd of Moharram falls on Wednesday, Til, Gehun (wheat) and Ganna (sugarcane) will be dear, but there will be plentiful melons and locusts. The same event coming on Thursday will give plentiful rains with good crops but the winter will be very cold. If it comes on Friday, grain will be cheap, there will be plenty of milk and a bumper crop of wheat. If the 3rd falls on Saturday, cattle will die in great numbers. [These prognostications about weather are given out by one Fateh Ali Bhaddari of Azamgarh District.]

(*To be continued.*)

NOTES.

Mixed crops. The Indian custom of growing gram and wheat together as a mixed crop is well known and has often been described in the literature. The practice is particularly common on the black soils of Peninsular India and also in the tract comprised by the Western Districts of the United Provinces and the Eastern Punjab. The advantage in mixing the crops is generally considered to be the insurance obtained against an entire failure of the harvest in years of short moisture. Under such conditions, the deep tap root of gram is supposed to reach the lower layers of the subsoil and to abstract moisture therefrom.

The mixture, however, has another advantage and this is concerned with the nitrogen supply. On the black soils of the Peninsula, it is exceedingly probable that denitrification is common during the monsoon phase, and that the amount of available nitrogen is small at the time when the *rabi* crops are sown. In November and December, the wheat crop in this region looks very thin and pale, and the foliage is wanting in that robust appearance characteristic of wheat grown on land moderately rich in available nitrogen. If the supply of nitrogen is limited, it would obviously be a great advantage to the wheat to be grown mixed with a crop like gram which is able to make use of atmospheric nitrogen and so relieve the pressure on the combined nitrogen. A similar state of affairs exists in Northern India. The marked response of wheat to organic manures on the somewhat sandy loams of North-West India, where wheat and gram are grown together, indicates that here too it would be an advantage to limit competition for the nitrates dissolved in the soil water.

An interesting confirmation of these ideas has just been obtained in the Botanical Area at Pusa. Of late years, a number of new wheat crosses have been worked out between Indian types of high

grain quality and rust-resistant, strong-strawed English kinds. The work is now in the sixth generation and new rust-resistant forms have been fixed with exceedingly strong straw and vigorous rooting power. These withstand wind, retain their erect habit up to ripening time, and stand out in strong contrast to ordinary Indian types which always lean away from the prevailing wind. The single plants of these crosses were sown as usual grain by grain in October 1915 in small plots of three lines each and the cultures were separated from each other by a line of gram. The field was therefore a mixed crop of wheat and gram in the proportion of three of wheat to one of gram, a mixture, as regards the relative amounts of the two constituents, not unlike that often met with in practice.

As the wheat ripened, a curious phenomenon disclosed itself all over the culture field. The outer lines of wheat of each plot next to the gram were distinctly taller than the middle line and appeared to be more vigorous. These lines were growing in soil next to the gram and therefore would be expected to obtain more nitrogen than the central line of each wheat plot. At harvest time, weighings were made of the seed of 20 plants taken from the middle line of plots and from the corresponding outer line next to the gram. The first of these plots was about the centre of the field where the soil was not very fertile. The second was towards the southern end of the culture field where the natural fertility was considerably greater, due to accumulations of silt formed by the natural terracing of the field. Care was taken to select representative samples of the whole. The results were as follows, the weight of the seed of 20 plants being expressed in grammes :—

	Row next to gram	Inside row	Percentage increase
1	178·4	108·5	65
2	302·0	241·2	25
Total ...	480·4	349·7	Average 45

The total difference in favour of the wheat next to the gram is therefore 130·7 grammes and the average increase is 45 per cent.

Weighings were next taken of the grain of the whole of the outer and inner lines of two cultures from the southern end of the field. The results, in grammes, are given in the next table :—

	Outer row	Inner row	Outer row
1	594	470	635
2	661	548	621
Total	1,255	1,018	1,256

In the first case, the average increase of the outer lines above the middle line is 145 grammes or 30 per cent. In the second case, taken from the most fertile corner of the culture field, the average increase is less, namely, 93 grammes, or 17 per cent. It will be observed that, in all cases where the soil, judged by the vigour of the wheat crop, was richest, the difference between the yield of the inner and outer rows is less. This fact supports the explanation that these differences are due to the nitrogen supply of the wheat. Taking all four determinations together, the average increase in grain production of the lines next the gram is 34 per cent. above that of the middle line of each plot. The figures indicate quite clearly that there is a marked advantage in growing mixed crops of gram and wheat on soils where combined nitrogen is a limiting factor.—[A. Howard].

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The effect of Sulphur on crops. Attention was drawn in April 1914 in a note in Vol. IX, Part 2 of this Journal, to certain observations on the effect of sulphur on crops, and it was suggested that it would be worth while testing the effect of sulphur on soils where it had not been previously tried.

In 1915 such tests were made on the Ranchi Farm, quantities of sulphur from 10 to 40 lb. and gypsum containing some 30 lb. of sulphur per acre, being severally applied to a large number of plots of groundnut.

The effect was in every case very remarkable, the gypsum producing an average increase of 8 maunds per acre of groundnut,

and the plots to which sulphur or gypsum was applied being very much more luxuriant than the control plots.

As far as could be judged by appearances, 10 lb. of sulphur per acre produced as much effect as 40 lb., but the larger quantities gave slightly larger yields of nuts.

Twenty pounds of sulphur per acre applied to rape also produced a remarkable effect, the crop being very much more luxuriant and continuing to flower for quite a fortnight longer where the sulphur was applied.

In a paper in the *Journal of Agricultural Research* (Vol. V, No. 16, of January 17th, 1916) Walter Pitz, Assistant Agricultural Chemist of the Agricultural Experiment Station of the University, Wisconsin, shows by pot experiments with two soils, that small quantities of calcium sulphate may increase the growth of legume bacteria and the yield of red clover—an increase which is accompanied by a greater root development and an increase in the number of nodules. The smallest proportion of calcium sulphate used in his experiments would, however, even if calculated only on the top 4 inches of soil, connote an application of more than five times the largest quantity used per acre in the experiments at Ranchi; and it would seem probable that, in laboratory experiments with sulphur, increments of the order of 0·001 per cent. of the weight of soil would give more useful results than increments of ten times that magnitude.

The *Monthly Bulletin of Agricultural Intelligence and Plant Diseases* for December 1915, contains (p. 1629) an abstract of a paper by F. C. Rimes, Superintendent of the Southern Oreyon Experiment Station, on the effect of sulphur on alfalfa at that Station.

Many references are also given to previous papers on this subject.—[A. C. DOBBS].

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AN interesting note by Mr. Barnes, Agricultural Chemist, Punjab, has been received dealing with the **mineral constituents of cotton lint.** It arose from the supposed adulteration of raw Chiniot cotton by the addition of earth salts to increase the hygroscopic

properties and the investigation of such a possibility led to the discovery that the inorganic constituents of this cotton fibre were far more variable than had hitherto been supposed and the large percentage of magnesium chloride it contains seems likely to seriously affect the reaction of the fibre to dyes.

We quote Mr. Barnes' summary *in extenso* as it points to another factor which will have to be considered by the grower, breeder, and buyer.

" There appears to be no evidence of the reported practice of salting the cotton to increase its water holding capacity. Mr. Arno Schmidt reports that he has seen watering of raw cotton actually taking place, but this is a crude form of sophistication, and will certainly lead to deterioration of the fibre and cannot but come to the notice of the buying agents of exporting firms in India. It will thus rebound immediately on the persons practising this fraud and can be dismissed from the scope of this enquiry.

" The complaint of Messrs. Volkart that the Chiniot cotton contains an unusually high percentage of magnesium chloride seems to be true, but we do not think that this substance has been artificially added, for the analysis of sample No. 53 shows that it compares with other genuine samples in the amount of water and mineral matter which it contains. The assumption that cottons grown on saline soils will produce a fibre more heavily impregnated with mineral matter does not seem to be justified by the results, for alkaline soils are much more prevalent in the Punjab than in Bombay.

" The total amount of ash material in cotton fibre seems to have been under-estimated by previous workers who seem to have assumed that this was largely due to foreign mineral matter in the form of dirt in the baled cotton.

" The presence of highly varying quantities of silica especially seems to have escaped attention. I am inclined to lay considerable stress on the established fact that genuine cotton fibre may contain upwards of one per cent. of ash, and that the composition of this ash is variable and variable to a far greater extent than has hitherto been supposed.

"There is little doubt but that this will seriously affect the reaction of the fibre to dyes—how far it will affect the tensile strength and keeping qualities of the fibre remains to be shown. It is evidently a factor which both grower and breeder must take into consideration, namely, the nature and quality of the mineral salts taken up by different varieties of cotton grown in the same soil, and under the same conditions, and how far climatic variation will effect this, as well as the effect of these mineral constituents on the commercial value of the fibre."

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Abortion Bacillus. The remarkable discovery of G. C. Schroeder and W. E. Cotton on the persistence of the abortion bacillus in the milk of cows, and particularly the demonstration of the fact that in one case it was eliminated from a cow's milk for four and a quarter years, is a most interesting contribution to what was already known concerning the bacillus. As far as our preliminary investigations have gone in this direction, we find that the bacillus is present in the milk of cows in the herds we are using for our work, and this milk injected into healthy guinea-pigs does produce pathological lesions and death.

We collected in November last year a number of samples of milk from cows which were known to have aborted. Utmost regard was given to asepsis in order to eliminate all possibilities of extraneous contamination. Sterile tubes were filled by squirting the milk therein from some distance. With this milk guinea-pigs were inoculated intraperitoneally with quantities from 5 to 15 cc.

Before injecting the milk was warmed to prevent shock. We find that guinea-pigs can accommodate large quantities of milk without any discomfort. Workers in this laboratory have used as high as 30 cc. without untoward results.

The first guinea-pig died on the thirty-sixth day following the infection, the second on the forty-fifth day, and several between this later period and the fifty-sixth day. *Post-mortem* examinations of these pigs revealed the characteristic enlargement of the spleen. The lymphatic glands presented signs of degeneration. The liver

was enlarged, with whitish spots throughout its substance. In some of our guinea-pigs the characteristic changes in the organs were not so pronounced as recorded by Schroeder and Cotton, but this may have been due to the cold quarters reducing the vitality of the small animals, so that they died before any great degenerative changes had taken place. Further, our organism may be of a greater virulence. In all our autopsies the clinical lesion in the spleen was taken as suggestive of infection, and it was from this organ that our cultures of abortion were obtained. Spleen pulp spread over the surface of the solid tube media gave excellent growths in reduced oxygen. The bacillus obtained in these cultures possessed more rapid growing qualities than those obtained from material in the original host (the placenta and uterine contents).—*Report of Veterinary Director-General, Canada.*

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Root Pruning. This operation is performed in the case of those fruit trees which make a free growth, but produce little or no fruit. This operation also requires skill and experience. To do this properly, dig a trench in winter 3 feet deep around the tree and about six feet away from the main stem. Any root met with while digging the trench should be cut back to its inner side. If only few roots are met with at the above-named distance from the main stem, then dig gradually closer to the latter all around until you reach a point where root growth is profuse. Then cut off all the main roots to be seen with a sharp knife. When this has been done, mix the turned out soil with one or two dozen baskets of manure and return it to where it was taken from.—*The Fruit Garden in India.*

REVIEWS.

The Milk Problem in Indian Cities. By LEMUEL L. JOSHI, B.Sc., M.D., Municipal Analyst, Bombay. Published by Messrs. D. B. Taraporevala Sons & Co., Bombay. Price Rs. 5.

IT cannot be said that this work is an addition to the literature on the question of milk supply in the East as it really is the beginning of reliable written records and conclusions on the all-important subject of the milk supply to Indian urban communities. Dr. Joshi has a wide experience of the subject from the public health point of view, and although to some extent he deals with the technical or dairying side of the question the book cannot be regarded as a work on dairy technology, but rather as a lead for the educated public in general, and those engaged in safeguarding public health in particular, on the milk question in cities.

The picture which Dr. Joshi draws of the present condition of the dairy industry in India corroborates the findings of the Board of Agriculture at their Coimbatore meeting, and in no way does the author overstate the case here. After reviewing the present conditions of city milk supply, Dr. Joshi goes on to describe what he considers to be the reasons for the existing deplorable condition, and then he suggests certain remedies. The conclusions drawn as to the cause of the existing state of affairs are sound generally, and Dr. Joshi classifies remedial measures under three heads :—

(1) Economic, educational, and general measures.
(2) Sanitary measures.
(3) Legislative control.

In connection with (1) the author materially gives prominence of place to the breeding, rearing, and tending of a dual purpose

cow for India, or in other words, a breed of ox of which the males will be suitable for draught and the females for milk production.

The question of improved feeding, housing, and general care of the animal is fairly fully dealt with, and the difficult problem of the organization of cow-owners for the purpose of selling their produce and generally applying modern business methods to the industry is discussed. Co-operation is recommended as a means of solving this end of the problem, and it is a pity that Dr. Joshi did not give us more details as to how such co-operation might be applied in India. Throughout the work he quotes freely what has been done in other countries, and he might well have given more particulars of how co-operative methods have been applied to the needs of the dairy industry, especially city milk supply, in Europe and the Colonies. Not only so but the knowledge and experience Dr. Joshi exhibits throughout this work would well enable him to enlighten us as to how foreign co-operative propaganda could specially be applied to Indian conditions. Various measures to be undertaken by the State in the direction of educating the cow-owners and the public are discussed, and the author's suggestions here generally follow the lines of the recommendations of the Board of Agriculture.

Dr. Joshi rightly believes that the economic, sanitary, and other measures advocated should take precedence of legislative action, but he regards the latter as a necessary corollary of dairy educative propaganda. His recommendations as to the fixing of standards of quality are in the main sound, and the difficulties of differentiating between cows' and buffaloes' milk and fixing standards applicable to both are dealt with. The question of estimating the cleanliness of milk by its bacterial contents is very fully discussed, but although the author is cautious in his recommendations as to fixing standards of bacterial contents, here the practical dairy expert will not follow him, until it is more clearly established that the figures given as quantities of germs present in given quantities of milk are really what they represent, and until this fact can be readily demonstrated to the ordinary well trained dairy manager.

On the whole, the work is a sound treatise on an all-important subject, and the conclusions drawn by Dr. Joshi might with slight modifications be taken as the basis of dairy reform here.—[W. S.]

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Well Waters from the Trap Area of Western India. By HAROLD H. MANN, D.Sc., Principal, Agricultural College, Poona (Department of Agriculture, Bombay. Bulletin No. 74 of 1915). Price As. 6 or 7*d*.

INDIA is at times visited by severe droughts which affect considerable tracts of country, and cause much distress to the agricultural population. Government tries to render the work of the cultivator as far as possible independent of the variations of the season by the provision of suitable irrigation facilities. By anicuts and canals fullest advantage is taken of the waters in many of the great rivers. Irrigation from wells is also made use of to a considerable extent and has the advantage of being cheap enough to be within the means of the cultivator.

In Western India, except for a comparatively small area, served by canals and tanks, almost the whole of the irrigation is conducted from wells. The total number of wells is enormous and they are a very important factor in the agriculture of the country.

The problems presented by well-irrigation are hence worth a closer investigation in their chemical, geological and engineering aspects than they have received in the past. Dr. Mann's paper is therefore very welcome.

In the trap area, the water in a well is almost always what may be termed " fissure water," that is to say, it is not a generalized subsoil water which is tapped, but water flowing in definite fissures in a definite direction. In digging a well one has to take his chance of meeting a fissure containing flowing water. This makes any attempt at digging an ordinary well by tube boring or by any other means of digging a *narrow* trial hole, of very uncertain value, unless the presence of water has been made fairly certain beforehand.

The above is, of course, the general case. But there are a considerable number of enclosed valleys even in the typical trap area where there is a generalized underground water supply over a limited area.

Analyses of typical well waters are given by Dr. Mann. Attention is drawn to the fact that the application of certain well waters makes the soil very impervious to water and hence very hard and difficult to wet. In such cases the waters contain a large quantity of alkaline bicarbonate and a small quantity of other sodium and potassium salts. If chlorides or sulphates in larger quantity accompany these alkaline bicarbonates, they are relatively innocuous; but if the bicarbonates of the alkalies are present in quantity greater than the chlorides, they are injurious. The actual effect seems to be a destruction of the tilth of the soil owing to a deflocculation of the colloid clay material so that on mixing with water the solid matter remains suspended for practically an indefinite period.

As to the amount of dissolved salt in the water which will render samples of water unsuitable for irrigation, it has been found that, so long as these do not contain a large excess of alkaline carbonate or bicarbonates in excess of the amount of lime salts and of the chlorides and sulphate, well waters are useful for irrigation until the amount of salt reaches 200 parts in 100,000 (or 0·2 per cent.)

At Dhulia a systematic study has been carried out to ascertain to what extent the character and quantity of salts vary at different times of the year in the same well. The extraordinary constancy in the composition shows that the water which is drawn up from rock fissures in wells like that at Dhulia is not surface water, but represents the tapping of a very considerable underground water reservoir. This might have been also concluded from the fact that the supply, though diminishing in the hot months, never ceases.

An examination of the waters of some wells near Surat proved the interesting fact that in this part there is not a general reservoir of subsoil water. The water differs in composition and depth in different wells within a short distance from one another. When

a well is emptied the water usually flows into it chiefly, if not entirely, from the eastern side.

Nearly all the wells in this part of Gujarat are somewhat salt due to a continual seepage from the sea. During the famine years (1896 and 1900) the sources from which the wells in Gujarat are usually supplied were dried up and many of the wells gradually became salt. Many have remained so, and useless ever since : others have gradually after several years become sweet again. This can only be the result, it seems, of sea water coming in, when the fresh water current from the East, which usually kept it back, failed. The effect of short rainfall in Gujarat on the character of the water in the wells is thus serious and the permanent effect of a long drought may not be limited to its action on cattle and men. It follows also that there is much danger in utilizing too great a proportion of the water available in such wells, and the haphazard use of well water for irrigation purposes ought to be put a stop to.

The author is to be congratulated on this excellent work and the results of his further studies will be awaited with considerable interest.—[J. S.].

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A Soil Survey of the Guntur Delta. By W. H. Harrison, M.Sc., and B. Viswanath, Bulletin No. 70, Department of Agriculture, Madras. Price R. 1-8 or 2*s*. 6*d*.

The importance of a systematic study of the field differences in soil is recognized by all interested in agricultural work. Not only is the result of the soil survey of a locality of great help to the practical farmer, but it also is of use to a wider public in as much as it furnishes an important factor for the determination of land values.

Dr. Harrison and his assistant have just published a second instalment of the result of their survey of the Madras soils, the first referring to the soils of the Tanjore delta (Bull. 68). The present work deals with that portion of the delta of the Kistna river which lies in the Guntur district and is under the Kistna irrigation project. 111 samples of soil were collected from typical fields whose recent

manurial history could be obtained and which are under paddy cultivation.

The results of the analysis, which consists of the estimation of lime, magnesia, nitrogen and total and available potash and phosphoric acid, are entered in a table and also shown graphically in maps of which there are many.

A study of these maps is very instructive and serves as a guide to the manurial requirements in different areas.

It is seen that the nitrogen content of the delta soils is low and the introduction of special manurial methods with the object of rectifying this would lead to great benefit. It is further seen that the effect of the river silt profoundly modifies the manurial character of the soil of the delta. The silt of the Kistna river is rich in lime and magnesia and total potash and phosphoric acid, and therefore it would be expected that the soils which come under its influence would materially differ from those not affected. Thus it is found that the coastal soils and those in the centre of the delta are generally clearly demarked and are of the poorest quality. This fact would appear to furnish an argument in favour of the conservation of the river silt.—[J. S.]

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CONTENTS

SIR EDWARD CHARLES BUCK, K.C.S.I.

In Memoriam.

Sir Edward Charles Buck, K.C.S.I.

In the early days of July intimation reached Simla that Sir Edward Buck had died in Rome where he was attending the meetings of the International Institute of Agriculture as representative of Great Britain and India. Thus did the veteran end his days as he would have wished, faithful to the trust which he made his own nigh fifty years ago.

The name of Sir Edward Buck will always be associated with the establishment of an agricultural policy for India. He may not have had that close association with agricultural experiment which has become the feature of more recent years. But he laid the broad lines of principle on which have been built up our Agriculture, Settlements and Land Records, Statistics and Famine Relief, and he is responsible for the sound foundation upon which the general revenue system of the Indian Empire rests. It was not his to see the later fruition of his efforts in the great expansion of agricultural investigation which came with Lord Curzon's Government, for he retired from the service in 1897; but to the end he kept in touch with its activities, and nearly every year personally saw its progress in his loved Provinces of Agra and Oudh.

Sir Edward Buck was a great personality, full of ideas and of extraordinary singleness of purpose. His whole career was devoted to Revenue from the days that he arrived in the North-West Provinces as an Assistant Collector in 1862 till he retired, after 15 years' service in the Government of India, in 1897. In his retirement he still kept up his interest in India and its problems, and his name will always be held in affectionate remembrance not only by the hosts of Europeans and Indians who enjoyed his personal friendship, but also by all who have at heart the real development of India. He was "a very perfect gentle Knight" and his memory will for long remain green. May he rest in peace!

EDITORIAL.

WITH the next issue of this Journal we shall introduce certain changes which we trust will tend to popularize it. Through the eleven years of its existence the Journal has maintained the high standard of excellence with which it started. That standard, it is hoped, will be continued; but there is a feeling that the Journal might, without detriment to its traditions, be made of more general and popular interest. While therefore it will contain, as in the past, articles on specific agricultural and scientific questions, an attempt will be made to widen its scope so that it will be more the Journal of the Agricultural Departments and of the agricultural workers of India.

We shall therefore welcome contributions from all who are interested in Agricultural and Veterinary matters, Irrigation problems, Co-operation and Agricultural Economics and, in particular, from those who have the practical problems of agriculture to face—the Planting Community and the large Zemindars of India. To them our columns will always be open, and we shall welcome all enquiries or criticisms they may address to us.

On this broader basis we trust that the Journal will enter upon an era of increased popularity and prosperity.

THE CONTROL OF FLIES AND VERMIN IN MESOPOTAMIA.

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Lately Entomologist in the Imperial Department of Agriculture for India.

[We have much pleasure in publishing this article from the pen of our former colleague Prof. Maxwell-Lefroy.

The Indian Agricultural Service—both European and Indian—has responded nobly to the Nation's call and our best wishes follow the present detachment of eight Pusa Assistants who have volunteered for service in Mesopotamia. May much success attend their efforts to alleviate the conditions in which our gallant troops are living, and may they return safe and sound, with the consciousness of a duty well performed.—(*Editor.*)]

There have been urgent reasons for dealing with flies and vermin among the forces in Mesopotamia this year, and I was fortunate in being sent up at the end of April to investigate and decide what could be done. Even on the way up, there was entomological work to do. The hospital ship on which I travelled from Bombay had been long in the tropics and was full of small red ants which were a sore trouble to the wounded and sometimes worse. As the ship was going up empty, there was full scope for work and after failing with one method, we succeeded with another. Baits were put down (usually syrup on rags) and the trail of ants to the nest traced back. The nests are all behind wood-casings and the cracks of exit were oiled with a mixture of paraffin and lubricating oil. This isolates the nest inside with the queens and the workers outside cannot bring food in. In three days there were no more trails or nests discoverable and the plague was under control.

Basrah was hot and stuffy but not markedly plagued with flies; but as one goes up river it gets worse at every camp till the climax is reached at the most advanced post where Corps Head-quarters are situated. The flies are mostly the Housefly type, *Musca*, of several species probably, a few Blow flies of the *Calliphora* type, and some *Stomoxys*. The last is a nuisance on the river as it bites so sharply but it is not a disease-carrier and is not really common on land.

To fully appreciate it the abundance of flies has to be seen and still more to be suffered. The tents and trenches are full of them. By night they sleep in masses on tent roofs, etc., in the morning they awake to furious activity as soon as the sun has warmed them, till midday they feed and fly and buzz; then they seek deep cool shelter if it is hot, say over 110° F. in the tent, and go to sleep. In my tent they preferred to get under the bed on the sides of the pit in which one lives. At evening they start again and are very active from 5 to 7. When one has been driven crazy, it is good to go and see the patient resignation of the sick and wounded and therefrom to learn control and resolve more strenuously to destroy the scourge. And then one remembers that nearly every disease in Mesopotamia is one that is carried by water and flies only, and one realizes that the fly is really a serious factor in this campaign.

Another entomological problem is of some importance in Mesopotamia, and this is the control of vermin and sand-flies, fortunately no difficult matter. The former convey relapsing fever and typhus, the latter carry sand-fly fever; both are the cause of irritation, the sand-fly especially; there have been cases of serious septic sores from sand-fly bites and the sand-fly has been one of the real plagues of life. Fortunately there is a cure for both. In 1904, the use of Crude Oil Emulsion was first introduced by the Entomological Section for vermin on animals; early in 1915, a refined form of this was shown to the War Office, and in May was adopted as the official vermin remedy for the army. It is now being made in large quantities in Bombay and sent up to Mesopotamia. In the Army it is known as "Vermijelli," but as this is a

registered name, the property of a firm in London, it is called "Sand-fly and Vermin Ointment." It has the merit of keeping off sand-flies and mosquitos, if rubbed very lightly on the hands and face. I had one tube with me in Mesopotamia. I did not realize the sand-fly was there and was badly bitten the first night; I was never bitten again, I used no net and all who shared my tube found the same. It is now being issued for this purpose. For vermin the emulsion is rubbed on the hairy parts of the body and on the seams of clothing; under-clothes are washed with it and dried without rinsing so that the clothes are lightly impregnated with it.

With regard to flies there are really three problems in Mesopotamia, the control of flies in camps, trenches, etc., in towns and with moving bodies of troops. The first is the important one because it is the biggest and, in some ways, the easiest to deal with. The breeding places in camps, trenches, etc., are of three kinds. The latrine trench is far the worst, accounting for probably 90 per cent. of the flies; the accumulations of stable manure, and the accumulations of refuse and offal account for the rest. The latrine trenches are about 18 inches deep, a foot long, six inches across; a series are dug side by side, according to the number of men. They are filled up daily. They offer the ideal breeding place for flies and they swarm with flies laying eggs when they are in use and are solid masses of maggots in a few days. Flies emerge from trenching ground in hordes, get their first meal at the nearest trench then in use and then distribute themselves over the camp.

Stable manure was comparatively harmless owing to rapid desiccation; only when small amounts were swept up with dry litter and so preserved from drying did one find maggots and the manure is nearly all dried and burnt. Kitchen refuse and offal are usually burnt or buried but would easily breed flies. The greatest care is usually taken and it is only carelessness on the part of the sweepers or camp cleaners that allows this material to breed flies.

In most places in Mesopotamia there is absolutely no other source of fly breeding; the land is flat, dry, absolutely barren as a rule; there is no shade, a fierce sun bakes it, a dry wind blows furiously. Only where man is, can there be shelter, food or breeding

places and there is no man but soldiers in the war area. There are stories of bodies of men trekking into the bare open country and finding hordes of flies, but they took these with them. When one comes out of the trenches, flies settle on all the areas shaded by one's *topee* or oneself and on all the shady parts of one's horse; they travel on one thus for miles, unable to fly away in the fierce sun. In this way one carries swarms of flies and a body of men, when they camp, will naturally find their tents full of flies.

No place strikes one as so easy to clear of flies as a camp, as all is done in full view, there is nothing hidden and one can control everything. There are no houses, no back-gardens or filthy alleys, no refuse dumps or collections of rubbish. It is a matter of deciding what to do and having it done.

The second problem will be more difficult because it is not so easy to control a town. In Basrah and Amarah there are large areas of camps, with streets of houses not far off; the problem is not so simple because of the uncontrolled breeding places of the native houses, and it is more a question of extensive fly killing (as described below) than of prevention.

The third problem again is difficult because of the limited resources of a moving body of men. Such a body of men will not suffer from the flies they breed; they suffer from the flies bred by other moving forces before them and there are camping grounds on lines of communication where you arrive to find that swarms of flies greet you and millions are then emerging; that means that ten days before a body of men camped there, used latrine trenches, and probably did not trouble too much about the disposal of kitchen refuse and offal.

Having examined the problem and especially having seen what was needed for the trenches, 'the field hospitals and the head-quarters and other camps, it was a question of getting supplies and a staff of men to carry out the obvious measures. All the supplies that went with me from Bombay were snapped up at once and much more was needed. Everyone in charge of hospitals particularly needed help and supplies; it is a real experience to go round the tents of a cholera or ordinary hospital, and to see what a ourse

the flies are to the men. Then one sees the operating tent and realizes that flies may come 100 yards from a nearby latrine to vomit their last food on the exposed tissues of a patient; one sees flies settling on a fresh wound, and the men fighting them off while it is dressed. No wonder every single person is keen to help the fly campaign and that every possible assistance is being given to those who are trying to reduce this pest.

A short simple set of instructions was prepared and issued; the measures recommended are discussed here in turn.

1. As far as possible, replace latrine trenches by tins and incinerate. This system is very widely used: tins are sunk in the ground to receive fæces; nearby is a small round incinerator consisting of a circular wall three feet high with a grating across of iron rods and two air inlets below; dry litter and any dry material is put in, lit and it burns slowly; on this the material is incinerated. This is not always possible particularly in the trenches; but one battalion had an incinerator for its front line latrine: and where this can be done it is the proper thing.

2. Where incineration is impossible and deep trenching is impossible, then each latrine trench must be treated. After trying pesterine and fuel oil without effect, it was found that ordinary burning oil, as issued there, was effective; a trench treated with oil does not get infected with maggots and if oiled when it is filled up, many maggots are killed. There is much oil available, the crude lighting oil of the Anglo-Persian Oil Co., obtainable near Basrah, being quite suitable.

3. Oil should be used even with tins as it prevents flies settling and feeding on the excreta. A great deal of the diarrhœa and intestinal diseases prevalent must be carried by flies directly from the fæces of infected men and oiling prevents that.

4. Kitchen refuse and offal are to be burned or oiled and buried. This is obvious and is rendered more important by the fact that a great many goats are slaughtered by native regiments, in their own way, anywhere near their lines. There is a great deal of indiscriminate goat-killing going on wherever there are native

units and this material would breed flies. The absence of blue-bottles shows how careful the men are in this matter.

5. Horse and mule droppings are to be collected and burned or spread out to dry. As a rule the droppings are wanted for the incinerators. The heat and dryness are such that in a very short time, house manure is too dry for flies to breed in it; the only trouble has been with the individual *saises* of officers' horses who may be careless and breed a quantity of flies; where there are regular horse or mule lines the greatest care is taken.

6. Trial of fly poisoning with sodium arsenite showed it to be an extremely effective method; fortunately I had been able in Bombay to get 50 tins of weed killer, which was crude arsenite and worked very well.

A mixture is made of arsenite half a pound, *gur* two and a half pounds, water two and a half gallons. This is a convenient amount for a kerosine tin. In this a gunny bag was dipped and hung up. A shelter tent or a covering of mats is advisable or the flies will not come in the hot part of the day, and the gunny bag must be kept moist. Flies come in swarms, feed and die there on the spot. The solution is weak enough not to affect them till they have fed; if made too strong, they are affected before they get a fatal dose. It is possible to fit up strips of gunny on the roller towel principle so that it dips in the tin; as it dries and gets too concentrated water is added.

This simple poison, devised originally by Dr. Berlese of Portici, Italy, works beautifully; the flies are thirsty and hungry; they smell the *gur*, they come in shoals; blue-bottles come as well as *Musca*. The slaughter is very great and the effective range appears to be at least 200 yards and is probably much more. This means that to keep a camp clear one wants a fly-poisoning station every quarter of a mile or so. By having the poisoning done in a separate place there is no risk from dead flies and it is best to put the poison at a point between the latrines and the camp.

7. In the trenches flies collect in masses at certain places at night and at midday. They particularly like canvas or tarpaulin coverings and sheltered corners in dug-outs. With a spraying

machine and suitable liquid, one can kill flies in bulk. The choice of liquid is easy; two only are at present known, both of which have been extensively used in Europe and Egypt since they were discovered last year. For the trenches we are using the oil-spray, a special grade of mineral oil to which is added a small amount of aromatic essential oil such as citrovella. In England this is sold as "Flybane"; in Bombay, thanks to the help of the managers of the Standard, Vacuum and Asiatic Oil Companies, the nearest grade of oil to that selected in England has been found and is being used.

8. Hospital tents and buildings require other methods. Formaline can be used for fly poisoning; but the "Miscible fly spray" used in Europe and Egypt will probably give the best results; it is undesirable to use the oil as it taints milk and food; but this new fly spray, whose laboratory name is *Exol*, is being sent up for hospital use. It is not poisonous or inflammable and has only a slight smell; it does not taint food. It is mixed with water and sprayed in the air. Flies fall to the ground paralysed or dead. It is not yet certain whether the formula used in Europe will succeed in Mesopotamia owing to the very high temperatures but this has to be ascertained and the formula varied if necessary. Thanks to the Medical Store-keeper at Bombay, large quantities of this have been made. At the request of the War Office the formula of this spray has not been published as the ingredients are not unlimited in supply. When the Army has had all it needs, the formula will be published and the public can get the liquid.

For hospitals, an ample supply of netting, mosquito nets, etc., has been essential. It is absolutely necessary to prevent flies getting at the excreta of cholera or dysentery patients for instance and in tents this is only possible with nets. In the same way the disposal of the excreta is very important and all field hospitals use incinerators.

A special problem arises in the case of bodies of men moving. I believe that it is better in these cases to have no trench latrines, but to mark off a space of clean and hard ground and use that. The heat and dryness is such that flies cannot breed in the material

which desiccates at once. This goes against the sanitary expert's ideas but I believe it to be sound in all cases where the moving body is not going to stay more than three days.

These are the methods recommended and the three important ones are—

(1) Disposal of fly-breeding material.

(2) Fly poisoning.

(3) Fly spraying in trenches and hospitals.

It was obvious that to carry these out there should be a special subordinate officer attached to each large camp and to each division. He would naturally be under the orders of the Sanitary Officer but his special business would be flies. He would inspect the whole of the camp or the trenches occupied by his division, hunt out fly-breeding material, report cases of bad sanitation, see that latrines are oiled. He would be in charge of the fly poisoning, he would show men how to use sprayers and organize a gang to systematically slaughter flies with sprayers.

Such work is best done by men used to spraying and similar operations. Eight were required for the different places in Mesopotamia and I proposed going to Pusa for them, taking volunteers from the Imperial Pathological Entomologist's Section, as flies have been their business for years, and also from other sections, or from Provincial Departments if necessary.

Captain C. F. C. Beeson, Imperial Forest Zoologist, who was with me in Mesopotamia, remained there and would be in charge of these men and the whole work.

This proposal was accepted and I returned to India to organize supplies of arsenic, sprayers, etc., and to get eight men. The selected men are shown in the photograph which accompanies this article. They left Pusa on Wednesday, July 5th, for Bombay whence they proceeded to Basrah and Amarah. They were recruited from the entomological and mycological sections with one from the veterinary staff. They have rank as Indian Warrant Officers according to their pay and will be on duty in Mesopotamia probably till October. In the first place they join Captain Beeson to get experience of military conditions and then they will be posted out.

PLATE XXII.

GROUP PHOTOGRAPH OF THE MESOPOTAMIA VOLUNTEERS.

Seated, from left. Mr. H. N. Sharma. Mr. S. N. Mitra. (Temp.) Lt. Col. H. Maxwell-Lefroy. Mr. P. G. Patel. Mr. L. S. Joseph.
Standing, ,, Mr. P. C. Kar. Mr. P. Narayanan. Mr. Dwarka Prasad Singh. Mr. T. V. V. Subramania Aiyer.

The Agricultural and the Forest Research Institutes are to be congratulated on supplying the officers and staff for this work. No one anticipated that the work of the entomological sections would be of vital use in this war, and it is a satisfaction that the work done years ago in the Imperial Department has been of direct use and that the men and methods can be supplied for the present campaign. Their work will be very much appreciated in Mesopotamia and we hope all will return well with a successful piece of work well done.

AGRICULTURAL EDUCATION.

BY

WYNNE SAYER, B.A.,

Assistant to the Agricultural Adviser to the Government of India.

I. Introduction.

On the subject of agricultural education much has been said, many methods put forward and as many condemned, and a great deal of the discussion has been at a loose end. A partial acquaintance with a great many different systems and methods used and employed in the furtherance of agricultural education in the United States of America, Japan, Germany, England, etc., will suffice to show that the subject is a complex one requiring close consideration.

An examination of the different methods employed in different countries leaves one with a definite substratum of general principles which we may try to adapt to our local conditions. The first efforts will of necessity be largely experimental, but from the experience thus gained we can go on making changes in our system as they are proved necessary; we have therefore to learn a lot before we can hope to arrive at any semblance of finality in our system of agricultural education, and this should be taken for granted by all parties concerned. As things stand at present we have three classes of people to educate, each of whom, in his own way, influences agriculture:—

First—The ryot, on his own land. He represents present agriculture in the active sense.

Second—His children who represent the active agriculture of the future, both workers and teachers.

Third—The landowning class, whose influence on agriculture is of the greatest value when properly applied and whose sympathy and interest can assist in the propagation of sound agricultural practices all over India.

These three classes linked in a proper appreciation of improved agriculture and its possibilities could create a new India and they wait on agricultural education to show them the way.

II. Development of English Education in this Country.

It will be well to take a cursory glance at the development of general education in this country before proceeding to the question of agricultural education, as it will enable us to better understand what effect it has had in the community and how it has affected agriculture. It was after Lord Macaulay's famous Minute of 1835 that the Government of India definitely decided in favour of English education. Education on Western lines was in fact becoming necessary as there was a growing demand for it. Another forcible reason was that as Government was settling down to administer and consolidate its possessions in India it required public servants with a knowledge of English to help its European officers in carrying on the work, getting into touch with, and making its intentions known to, the people.

The Universities of Bombay, Madras, and Calcutta were established in 1857, the Universities of the Punjab and Allahabad being founded in 1882 and 1887 respectively. As science was not so well advanced in those days, the education in India promoted by these Universities came to be more literary than scientific.

The English system of administration with its regular supervision of every detail and its foresight required a larger number of subordinate agents than was required in previous indigenous administrations.

Indian administrations in many cases under-paid their staff and winked at their recouping themselves—the natural result of under-payment.

The British system *gives* what is considered to be *sufficient* pay to remove any necessity for corruption. Thus those who received an English education got a large increase of pay compared with what they were used to under Indian administrations.

This acted as a great stimulus to Indians to seek an English education. It was regarded as a royal road to fortune and rightly so.

There was also a great demand for lawyers and pleaders consequent upon the fact that it was necessary to reduce the chaotic condition of the Indian administration, notably as regards land tenure and ownership to a definite legal status.

Further the opening of railways and the establishing of cotton mills and other industries provided employment for those who were only half-educated, or rather not up to the standard required for Government service and the law.

Thus the stream steadily began to flow in one direction and the effect spread to the remotest corners of the land and having saturated the minds of all and sundry it became a fixed belief. Hence there is stamped on the life of India one great goal, an English education followed by a Government billet.

There was an idea that the educated class would disseminate what is best in Western literature and science to their more backward brothers through the medium of the vernaculars, but this pious wish has more or less fallen flat.

Railways, irrigation works, Public Works Department, and factories have provided employment for numerous artisans, and from this the idea has grown up in a large section of the literary and agricultural classes that to stop in your village means starvation unless you have a large holding.

All this was brought about by a condition of things which could only be a transitory one based as it was purely on an artificial demand.

The tide still sets the same way, but the opportunities are now far fewer. The craving for education remains the same, and probably always will remain, but it is high time to see what we can do to divert it into more productive channels. It was towards the

end of the nineteenth century that the Indian Government began to think that all branches of education required careful review, and the Universities Commission immediately followed. Since then Government has leaned towards an education less literary and more practical, and in many Universities the courses have been altered to keep that end in view.

III. Agricultural Colleges.

It will thus be seen that the craving for literary education exists in the literate classes and in the more influential and higher agricultural classes. It is these classes who are ready to take advantage of scientific education in agriculture.

It was at first thought that no higher agricultural education would be necessary beyond such as would enable those who had received the two years' course in agricultural schools to make efficient subordinates under expert officers and to make those who did not enter Government service into better farmers.

Agricultural colleges of the advanced type we have at present in India came with the development of the Agricultural Department, the idea being that as agriculture is the backbone of Indian prosperity we cannot give too much agricultural education in this country ; while therefore preference was to be given to boys who were brought up amidst agricultural surroundings ; yet these colleges were to be open to such boys of the non-cultivating classes as might have a leaning towards agriculture. In the initial stages in order to attract students for these colleges Mr. Mollison, Inspector-General of Agriculture in India, was in favour of putting a leavening of agriculturally trained men into the Revenue Department on the ground that it is the subordinates of the Revenue Department who really see the agriculture of the land and who on account of their knowledge of the economic condition of cultivators can help forward the work of the Agricultural Department—a thoroughly sound view for many reasons which might well have been developed.

With regard to agricultural colleges at the present time it is as well to make one point clear which is apparently misunderstood

in some quarters that they are not intended merely to supply subordinates for the Agricultural Department, but to provide a liberal and scientific education in agriculture for those who either aim at higher appointments in the Agricultural Department or desire to take up higher studies and research work in agriculture for their own sake. In many European countries there is an agricultural faculty on the lines of other faculties in the Universities, giving liberal scientific education in agriculture and sciences allied thereto and training men for research work. In these no training in actual agricultural operations is given as the object is to turn out specialists fitted to carry on independent investigations. These faculties provide liberal scientific education in agriculture and thus attract the very best talent. **We think that in India also for the general widening of agricultural education affiliation to a University is desirable.** So long as agricultural colleges are not affiliated to a University they will not attract boys from the higher classes of Indian society connected with the land. These classes require a true collegiate education centring round agriculture, not mere manual training in the details of each agricultural practice. When these facilities are provided a fair number from these classes will be forthcoming, and the men thus trained will take their places as leaders of rural society with a thorough knowledge of what to aim at in the development of their estates. The strength of English agriculture lies in the fact that practically every land-owning Englishman has a knowledge of farming and stock-breeding—it is part of his life; *noblesse oblige* is the reason for it and the fact is recognized from the King downwards. Thus it can be seen that this class furnishes the country with a set of pioneers and influential supporters in agricultural improvement; and India wants a similar class. It is unnecessary to lay down that they should go through the same courses as those intended for the subordinates of Agricultural Department. What is wanted is to enlist their sympathies by giving them an insight into the subject and to make them able to realize the value of research and experiment; to make them see that to better the condition of their ryots is to their own advantage as well; to turn them from supercilious onlookers into sympathetic

co-adjutors of the Department; and for this it is necessary to create a strong faculty of agriculture at the University. One agricultural college affiliated to a University will meet the needs of Peninsular, and another Northern, India: for the class of men they are intended for will not require a college at their gates. They will go to the two colleges in the same way as land-owning England goes to Oxford and Cambridge. The rest of the colleges might be turned into agricultural high schools of the type prevailing in America, or agricultural schools in Germany or Switzerland and will cater for the needs of the Agricultural Department in providing recruits for subordinate posts.

IV. Education of grown-up Farmers.

The provision of agricultural colleges does not complete the scheme. As the cultivators are mostly illiterate they do not value a scientific education and in order to make them value this for their sons we have to show them what agriculture on improved lines can do in the amelioration of their material condition, *i.e.*, we must convince the father in the only way in which he can be thoroughly convinced, *i.e.*, by practical demonstration. Demonstrations should be given on Government farms, at the cultivators' own homes, or at any convenient place, together with short courses on special subjects and it is here that the subordinates of the Revenue Department if they had an agricultural training could help best. So long as the agricultural classes are in the backward condition they are now, demonstration must go to them. They cannot be expected to spend time or money to any extent coming to it.

In India the system of caste has given the cultivator centuries of traditional experience behind his back. He knows to an inch what he can do with the limited amount he has to hand. We have therefore to be careful not to disturb this economic balance by an improvement which may be excellent but which would not work here, and it is the study of this economic balance both in this and in other greater and wider directions which is becoming a grave necessity, and which I hope to deal with later.

We are constantly reminded forcibly by print and illustration of the wonderful improvements brought about in other countries but this should be remembered that the introduction of improvements in Australia, Canada, and the United States is brought by capital. People who have little or no experience comparatively of the land they own, will always imagine a new thing to be much better than it is. They will risk more. They are new men in a new land. They have experienced few of the set-backs incidental to agriculture, and their hopes are correspondingly higher. Here in India it requires a strong man to introduce an improvement; it has to be a very strongly markéd improvement if it is to be adopted by the ryot; India has a rooted conservatism which cannot be realized by the countries like the above.

Again it is useless to blame the Indian farmer for adopting a policy of backing two horses in his farming. He grows two crops on one field; why? because he is not sure of the rains. Whatever happens he wins out on one and saves himself from starvation. The net yield of either crop, which is of course small, may be held up as a scandal by an expert who has never been in danger of starvation—but it is rare to find gross carelessness or gross neglect. The lives of too many depend on that crop—and that is the reason for the margin of safety so easy to refer to as wasted opportunity but so difficult to do without in the present day.

This then is the position. We can hardly teach the ryot his own job if we are limited to his circumstances. I venture to say no one can, but let me not be misunderstood. Agricultural Departments can open the gate to greater things by virtue of money. All improvements require capital. It is no use telling the ryot to do his own experiments—he cannot; his margin is too small but the Agricultural Department can do this by finding the capital for them. It is possible to bring an improvement within his reach when arrangements have been made for financing him so that he can safely take it up. To educate a man at an agricultural college and to send him back to work on a farm with no capital is useless. It may sound well to say he has been educated, but the effects will be nil.

The application of scientific knowledge to Indian agriculture opens out a vast field for increasing the out-turn of crops in India, *e.g.*, the yield of rice per acre in India is only about $\frac{1}{5}$ of that in Spain, that of wheat is about $\frac{1}{3}$ of the average out-turn in England, and it is only the Agricultural Department which has the capital, science, and skill that can undertake experiments for increasing the yield. A long series of tests is necessary before any definite agricultural improvement can be recommended for adoption, for jumping at conclusions to make a show and a splash in a country like India is fatal; time here is no object, to-morrow is also a day. Sooner or later the part that has been missed—slurred over, written away will be found out and a deep-rooted mistrust will oust the slow-grown confidence in the Department as a whole.

Now turning to the subject of demonstration as a method of education, while the evolution of new types and the replacing of inferior kinds by superior varieties are very promising lines of agricultural improvement in this country they will take time. We also realize that research must precede demonstration, but in the unequal agricultural progress of the cultivating classes in India there are many good practices which are known in one part and not in others. These require to be brought to the notice of more backward tracts. It will thus be seen that the greatest and the most immediately remunerative work lying ready to hand is not the introduction of some scheme requiring extensive, expensive machinery from abroad. It is the quiet, systematic transfer of the best agricultural practices from one province to another, from one district to another. The transplantation of rice seedlings known for years, nay, ages in many parts, was unknown in Chhattisgarh and there now ranks as the greatest improvement and rightly so. And it is here that the Agricultural Department has done wonders at a trifling cost, to quote but one instance. Such improvements impress the ryots, create in them an enthusiasm for progressive farming, and make them see the wisdom of receiving a training which enables a man with a wider outlook to pick the brains of others and apply them to his own use; for it is through this experimental avenue that an increase of revenue will come to ryots and the State, and it

should be obvious that **this is the most paying line of policy in laying the foundation for the demand for real agricultural education which will follow directly the ryot is convinced that there is something in it.**

As already pointed out above, agricultural improvements in most cases require capital. What is therefore wanted along with the spread of improvements is an effective method of obtaining capital, through as few intermediaries as possible, at a reasonable rate, and it is here that co-operative societies, though only in their infancy, can do most good. The passage of the money from lender to borrower *must* be simplified.

Agricultural seasons wait for no one, and to find a man, who has applied for a loan to get good seed, forced to fall back on cheap inferior stuff, owing to inability to get his loan in time, is what we want to avoid. The man who lends money on to the land must lend it when the land wants it, for the land is a bank whose doors are only open for deposits on really favourable terms for a very short time and this cannot be too strongly emphasized.

In the drier parts of India money lent to dig a well does more than this: the mere digging of it not only ensures the rains crop against possible failure, but it also encourages intensive farming and prolongs the cultivating seasons throughout the year and provides the ryot with employment for himself and family all the year round, weans him from idleness and litigation by making him live on his land. Where else does the digging of a well do all this ? Certainly in no town. It is for reasons like this that the co-operative societies want more money and it should be made available to them. Every pie spent thus by a primary society will return a hundred-fold by increasing prosperity and stabilising the revenue. The successful working of these societies will raise the moral tone of the cultivators, and this in itself will produce the better, steadier, more prosperous class which it is the aim of every country to produce.

V. Education of the Cultivators' Sons.

General observations.

What is the aim of education ? It is to make the nation more fitted to take its place as a nation among other nations, to hold its

own in the great economic struggles of the future, and in this coming struggle the dignity of labour will bear the brunt. Education should aim at producing a future race each better than his father at the family job and not necessarily a renegade from his ancestral profession. The present education is given totally irrespective of the parentage and of the future of the individuals : can it be wondered, then, that it all too often fails ?

While it may be admitted that some knowledge of the three R's is necessary to every man in the present stage of the evolution of the world, yet after this, specialization should commence as soon as possible, based on the needs of the man. Specialists at their best should be improvers of their fathers' work carrying on the family traditions ; one cannot emphasize too highly the fact that the national prosperity depends on the skill of its people, its varied development, and not on the super-literary education of a minority. And any education, which does not go deep enough to improve the man's chances of making a living to the good of the country, is no use. A highly educated class for whose labour there is no demand can only be parasitic on the country which educated it.

Education in rural schools.

We now come to examine education as provided in rura schools.

Many people with vague notions of agricultural education often advocate that in village primary schools the Education Department should begin to teach agriculture. Let us examine what this means. In primary vernacular schools boys have to learn reading, writing, and the doing of ordinary sums in arithmetic. Nothing more can be added at that age to their syllabus. It is sometimes said while we cannot teach agriculture we should teach agricultural principles ; but it is only developed intelligence that can follow the abstract—the children should go from concrete to abstract and from practical to theoretical. To cram them with these principles without their understanding them will only produce harmful effects, which will be very hard to

obliterate at school or college. What is required at primary schools is that the teaching should have more relation to the environment of the children. Text-books suitable for urban primary schools are not suitable for village schools and at present they are common. Hence children taught in village schools become rapidly divorced from their fathers' profession. In arithmetic also—teachers should deal with sums relating to payment of rent, real measurements of fields, calculation of fields' produce, etc., all things which will prove useful later on. But the difficulty is that in a large number of cases the scholars in rural primary schools are drawn from non-agricultural classes. Further, the primary schools are part of an educational ladder by which the clever boy whether from town or country can go up to the anglo-vernacular school and perhaps to a college. A different syllabus for boys in the rural school will handicap them in this respect. It will thus be seen that, while direct teaching of agriculture is to be deprecated, the giving of an agricultural tinge to the education imparted in the higher classes of these rural schools is a great desideratum, especially for those children who are not going up to the anglo-vernacular schools, and in this connection the value of nature study and school gardening cannot be over-estimated. It is the teachers who can, even with existing text-books, make the instruction suitable to the requirements of rural children. But this is where the teachers fail in a large number of cases—they miss the real point and the essential part: to sit in a class room and make remarks—is not what is needed. To go out and show the class what to observe is really what is wanted. Later on we find students lacking in observation and practical initiative and in manual skill; why? because throughout their whole training book-work has ranked highest, and it is only when they come out into the world they find that the position is reversed—much to their detriment. All over the world the cry is for skilled labour and always will be, and the man who is master of a trade is always sure of his living. It is an age of mechanism, a fact which India has not yet grasped.

Year by year the farmer becomes more of an engineer, and all trades tend to inter-connect to their mutual advantage. A big

farmer with one son trained as a mechanic and one as an agriculturist is both master of his land and his implements; with the rise in wages more labour-saving implements are introduced and the rise in the price of cattle helps as well. There can be no set-back to the use of agricultural machinery now; it has shown the world what it is capable of doing and the world, after one great gasp of surprise, is hastening to take advantage of the lesson.

It is important not to stifle the would-be mechanician in early life—we all remember the fate of the boy with the mechanical mind in our public schools. He used to be regarded as a social pariah, a creature of wild mind and wilder pursuits. Now he has ousted the classical people from pride of place throughout the land and what has happened in England should guide India; for the present war has given England an enforced mechanical education, the use of which will never be forgotten by the nation—for it is not a knowledge of the classics and certainly not a knowledge of law which is beating the German.

While we note the fact that manual training is provided in some of the schools in India we wish that it may be developed more and more, not as a fashionable fad, but as a prime necessity. It is often asked why it is that in spite of India's enormous cheap labour market and its proximity to the supplies of raw material, India cannot fairly compete with other western countries. The answer is that unskilled labour though nominally cheap yet in these days of machinery is ultimately dearer. Skilled labour has to be imported at a fabulous price, for the combination of unskilled labour and expensive machinery is the most expensive thing on earth. Any one doubting this need only give a cooly a mowing machine to work for a day. The cooly costs far less than a skilled man, but the repair bill of the machine swallows up the difference and the machine wears out far quicker.

Special Vernacular Agricultural Schools.

We now come to a consideration of the question what provision should be made for the sons of agriculturists who, after completing their vernacular course, are not going up for English education, but

wish to gain more useful general knowledge coupled with some instruction in agriculture. We think that in the case of these the provision of vernacular agricultural schools on the lines of that at Loni is most desirable. The boys at this age will be able to understand why certain results follow from certain causes. For the information of those of our readers who are unacquainted with this interesting experiment initiated by the Bombay Department of Agriculture we may say that the courses at Loni are of two years for boys who have passed at least the 4th Vernacular Standard, aged 13—18, 3 to 4 hours' are devoted to general education, while a similar number of hours work is done in the field. The whole of the cultivation is done by the boys and they all learn to make simple implements, the use and care of good steel implements as well as how to drive an oil engine which pumped water, bruised grain, etc. The teaching is entirely in the vernacular. As this was the first attempt of its kind board and tuition were provided free. The boys were mostly drawn from the sons of large cultivators with whom the Department was in touch though a considerable number of applicants were of the more literary class who were only admitted with great care. The boys trained at Loni have started real centres of interest in agricultural improvement on return to their own land. The success has been so gratifying that similar schools have been started in other divisions partly with Government money and partly with local subscriptions and endowments.

In starting such schools in different parts of India the exact age and educational qualifications for recruitment and the ratio between the general education and the technical education to be given at each school will have to be determined according to local conditions. But it would be well to bear in mind that practical training in each detailed piece of agricultural operations should not be considered as the only thing. What is required is to give them some knowledge of mechanical engineering and good general education with agriculture, so that the outlook of these boys may be widened and they may go away with an enthusiasm for their own calling and carry on their business in a really intelligent manner.

VI. Conclusion.

If a boy was made to work with his hands from the beginning he would appreciate the dignity of labour and his whole after-life would not be aimed at a position of *looking-on*. The aim is to assist a boy at his future work, not to divorce him to follow another calling.

The essential of most English engineers is the fact that they have been through the shops from the very beginning. I have known a man with a University degree who spent a month doing under-fitter's work in his father's Works. When India grasps the fact that to run a business successfully you must know the inner working of every step and detail, then we shall get captains of industry in other walks of life than money-lending and the law. Mere learning of science will not make a practical workman; it is the combination which is so strong.

Now is the time for India to make her effort. Her greatest asset is agriculture and the agriculture of the world was never so prosperous. Agricultural produce will rise in value after the war, to the benefit of India. Let her, therefore, take steps to put her chief industry on a better footing; better cultivation, better marketing arrangements, better financing of the rural population, a wider use of mechanical power is demanded. All the world is moving rapidly on the line of advance. And if India lags behind it will be a national calamity. Let her bestir herself and realize that the produce of the land is capable of a considerable amount of increase. This better state of things will be brought about by the education of the adult farmer and the rising generation who will farm when he has gone—in short by the education of India in a direction where best the talents of the nation may be fully and profitably employed to the benefit of all.

WHY ARE THE CULTIVATORS' OUT-TURNS OF WHEAT ON IRRIGATED LAND SMALL?

BY

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THIRTY-SIX maunds[1] per acre on two acres; twenty-eight maunds per acre on eight acres; twenty-five maunds per acre on thirty-two acres; twenty-two maunds per acre on eighteen acres; an average yield of about twenty-five maunds per acre over all these acres; these are the yields of wheat harvested at the Tarnab Agricultural Station this past May.

The average out-turn per acre on the 100,000 acres of irrigated wheat in the Peshawar District is less than twelve maunds per acre: is less in fact than half the average yield per acre over 60 acres at the Agricultural Station. Yet only 8 of the 60 acres received any manure; one-half of the area was irrigated once only; the remaining 30 acres received but two waterings; the rainfall during the period of growth was only 5·10 inches; harrowing and inter-cultivation were not practised; on three-quarters of the 60 acres wheat followed wheat; one ploughing with the Rajah, and two turnings with the country plough only were given to the land. In short, the Tarnab wheat would not appear to have received better cultivation than wheat in the neighbourhood.

Why, then, are the yields in the vicinity of Tarnab and those stated in the Season and Crop Report so very much less than the Agricultural Station out-turns?

The varieties grown at Tarnab are Pusa No. 4 and Federation, and these are noted yielders, but their superiority to local wheat in this respect will not nearly account for the out-turn of

[1] A maund = 82·12 lbs.

the Station being more than double that obtained by the cultivators.

To those who spend their lives with the cultivators on the land the enigma is made plain.

Firstly, it may be stated that the failure to produce high, or even fair, yields of wheat is rarely due to the cultivator's ignorance of good methods of growing the crop, or to the inefficiency of the implements employed in tillage, or even to the lack of a good yielding variety of wheat. These are simple reasons which readily occur to any one and are commonly assumed to account for India's poor out-turn of wheat per acre. The real causes are, however, more subtle, and less uncomplimentary to the Indian cultivator's intelligence than the above.

A large part of the cultivators' land yields two crops within the year, and actually realizes more money than bumper *ek-fasli* crops of 20 or more maunds per acre. By long experience each cultivator knows it is not safe to put all his eggs in one basket, and almost every one prefers moderate, upstanding crops of maize and wheat to fields of bountiful promise which stand in danger of disaster by wind and flood. This is the circumstance above all others that accounts for the disparity in the out-turn of wheat obtained at the Agricultural Stations and those recorded in the Season and Crop Reports.

There are numerous other conditions tending to reduce the cultivators' out-turns which should be considered but which are never stated in comparing Agricultural Station out-turns with those recorded in revenue reports. The wheat growers for example give at least 1/15th part of their crop to the harvesters in payment of their labour and probably each alternate year some wheat is lost on the threshing floor owing to bad weather and other causes.

Then holdings are small and the cultivators are poor; at times cereals follow cereals for some years, wheat following maize or *juar* with little rest or change to the land, and with scant manuring. Or if by chance the cultivators miss their turn of irrigation, sowing may harmfully be delayed, or a plague of weeds from a careless neighbour's field or an overgrown watercourse may choke their

wheat, when they are too busy, or may be too lazy to undertake weeding or to hire labour to perform the work.

Yet again and alas! many of the cultivators are in debt, and remain merely the unwilling servants of the *baniahs*, or almost equally unfortunate, they may be year to year tenants of the lease holders of extensive tracts, when lessees and tenants alike are bent on taking the utmost from the land at the minimum cost, regardless of the maintenance of fertility and cleanliness.

In examining the agriculture of a country-side in India, it is disappointing to find a large proportion of the crops adversely affected by one or more of the unfortunate conditions mentioned, and perusal of the Season and Crop Reports is very disappointing to the enquirer who is unacquainted with Indian agricultural conditions and practice.

It is perplexing to read that ten maunds per acre is the average out-turn on 1,000,000 acres of irrigated land, while in Agricultural Station Reports out-turns exceeding 30 maunds per acre are sometimes reported. Despite what has been stated in explanation of the cultivators' failure to produce good out-turns, and even admitting that Agricultural Station out-turns are sometimes estimated on quite small plots, the great disparity existing in the field and station yields is not yet clearly accounted for.

The enquiry may be pursued by comparing the treatment which produced 25 maunds per acre on an area of 60 acres at Tarnab, with the cultivation usually given to wheat in the vicinity.

Rotation and Tillage. The wheat at Tarnab was an *ek-fasli* crop, wheat following wheat on the greater part of the area. On the cultivators' land on the other hand, wheat is almost entirely a *do-fasli* crop, following maize, and the out-turns may therefore be about one-third less than the Tarnab *ek-fasli* yield of 25 maunds per acre. This practically means that the cultivators should harvest 16 maunds per acre from their *do-fasli* land and if the cultivators' out-turn is allowed to be 16 maunds per acre, there yet remains a deficiency to be accounted for to bring the cultivators' out-turn up to the Tarnab yield.

As wheat followed wheat at Tarnab, the land was turned over by the Rajah plough before 15th June. The cultivator's *do-fasli* land, on the other hand, could not be ploughed until 15th October, after maize was harvested. *Do-fasli* wheat is sown, in fact, within a few days only of the first ploughing of the land, and the cultivator's prospects of a good yield are here far poorer than at the Agricultural Station. But the cultivator's land probably produced a crop of maize, value Rs. 60 to Rs. 70, whilst the Tarnab wheat land was fallow and renewing fertility between July and October.

Irrigation. Tarnab has no advantage in this most important aid to wheat production, both the cultivator's wheat and the station crop being irrigated once or twice only.

Inter-cultivation. Again, Tarnab has no advantage, harrowing being impracticable on irrigated land, and hand-hoeing being too expensive and slow to undertake on 60 acres of wheat.

Weeding. The cultivators may lose somewhat in this direction, as they weed less thoroughly than at the station.

Protection. There are few cultivators' fields that are not damaged by browsing animals. At Tarnab no loss occurs in this direction.

Harvesting. The cultivators give 1/15th or more of their crop to the harvesters in payment of their labour. The station paid cash, and the final out-turn was therefore not reduced in weight by the harvesters.

Threshing. A steam thresher treated the Tarnab wheat a few days after it was cut, and loss of grain did not occur on the threshing floor. The cultivators, on the other hand, are very fortunate if they do not lose 1/20th of their crop during threshing.

Variety of wheat. Under equal conditions, Pusa No. 4 may be depended on to yield one maund per acre more than the local wheat.

Now the disparity in out-turn between the cultivator's yield and the station out-turn is nearly accounted for.

It has been shown that the cultivators lost weight of wheat approximately as follows :—

	Mds.	Seers.
(1) By practising *do-fasli* cultivation	8	0
(2) By neglect of weeding	0	20
(3) By the ravages of browsing animals	0	20
(4) By paying harvesters in wheat	1	0
(5) By bad weather during threshing	0	20
(6) By the inferiority of their variety of wheat ..	1	0
Add	11	20
The cultivators' actual out-turn	12	
	23	20

If to the above are added the small shares paid to the blacksmith, the carpenter, the barber, the chaukidar, and the 1/10th part so faithfully given by many to the poor in the name of God, it will be found that under reasonably comparable conditions, the out-turns actually produced on irrigated land are not as pitiable as they are usually assumed to be. The losses stated at (1) to (6) are chiefly due to circumstances over which the cultivators have little control; on no account is loss caused by mere ignorance of good practice in the simple art of growing wheat and, above all, it should not be forgotten that the profits realized by the cultivators are no less than those obtained from the heavy *ek-fasli* station crops, and it is probably true that over a period of five years or longer, the balance of profit would be in favour of the cultivators and well designed *do-fasli* practice.

By pursuing clean, careful cultivation and growing an upstanding superior variety of wheat, the cultivators can improve their out-turns, but they will not be encouraged to do so by belittling their actual attainments and placing before them high agricultural station out-turns without due regard to the difficulties that prohibit them from attaining these yields.

THE INFLUENCE OF THE WEATHER ON THE YIELD OF WHEAT.

BY

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1. Introduction.

THAT a general connection exists between the weather and the yield of crops is well known. This is referred to every year when the annual accounts of the Indian Empire come up for discussion. On these occasions, the Finance Member of Council often says that the Budget is little more than a gamble in rain. Sometimes, however, the matter is gone into in greater detail and attempts are made to treat the subject from the statistical standpoint and to apply mathematics thereto. The results obtained can hardly be said to be convincing. Apart from the scepticism with which many people regard attempts to prove a case by means of numbers, a little consideration shows that the subject is one to which, in the present state of knowledge, a mathematical treatment can hardly with confidence be applied.

The various meteorological factors like rainfall which are included in the weather are definite things and can be measured with reasonable accuracy both as regards amount and distribution. A wheat crop, on the other hand, cannot be treated in quite the same way. It is an assemblage of living machines which, by means of their chlorophyll corpuscles, are able to utilize the energy of sunlight in building up complex food substances from simpler materials such as mineral salts, water and carbon dioxide. There

is also an orderly development from the seedling stage to the mature crop and, during the whole growth period, the plants are competing with each other and are reacting to the various growth conditions—moisture, temperature, the supply of oxygen and mineral food materials in the soil, and the degree of moisture and movement in the atmosphere. Not only does the crop react to its surroundings but also the extent of this reaction depends on the stage of development reached. In addition, the various growth factors influence each other to a marked degree. For example, the rainfall not only affects the crop directly but also indirectly by altering the temperature of the air and of the soil, the atmospheric humidity and often the gaseous interchange between the soil and the air. Before we can even apply statistical methods to the connection between yield and a single weather factor such as rainfall, it is clear we must have some means of weighting the figures with reasonable accuracy. The effect of rainfall will vary with its amount, with its distribution, with the stage of development of the crop and with the character of the preceding monsoon. It will also influence, according to circumstances, the other growth factors such as temperature, soil aeration, humidity and air movement. As no two seasons in India are ever alike, it is obvious that we are dealing with too many mutually interacting variables to be able to define in mathematical terms the effect of any particular fall of rain. When we are dealing with the general effect of the weather as a whole on yield, the difficulties naturally increase with the increase in the number of factors. The most important matter connected with a wheat crop is naturally the yield of grain. This is the resultant of all the conditions of growth of which the weather is only one. It is clearly the merest speculation to attempt to deal statistically with the effect of any one factor on the system as a whole and it would appear that the subject from its nature is one to which mathematical treatment cannot possibly be applied.

There is, however, an alternative method of dealing with such questions. The growing of a wheat crop is after all a matter of applied physiology. The choice of soil, the preliminary cultivation

and the supply of air and water to the soil can best be looked upon as improvements in the conditions of growth, all of which are greatly modified by the weather.

During the last eleven years, the writer has obtained a considerable amount of practical experience in the cultivation of wheat and of the effect of the various conditions of growth, including the weather, on the yield. In addition to the rainfall, the soil temperature appears to be a most important factor while the aeration of the soil seems to affect the plant more than anything else. The results of numerous observations on these questions are dealt with in the present paper.

2. The Conditions of Growth of a Wheat Crop.

The soil conditions under which wheat thrives best have been known to agriculturists since remote antiquity and are referred to in the writings of such Roman authors as Cato and Varro. Modern investigations have naturally added to the knowledge possessed by the ancients but the cardinal importance of thorough cultivation for wheat and a soil of the proper texture and content of organic matter have been known and acted upon since the dawn of history. Provided the soil admits of copious root development and is fairly retentive of moisture, the amount of rainfall or irrigation water necessary for wheat is not considerable. A fair crop can be ripened with remarkably little moisture. Good soil aeration, by means of which the soil organisms and the roots of the wheat plant can obtain abundant oxygen and, at the same time, get rid of the carbon dioxide produced in the soil is quite as important as the water supply. Particularly is this the case during the ripening period when any interference with the aeration of the soil prevents maturation and also tends to induce rust attacks. The temperature of the soil is another important growth factor. Wheat, as is well known, is a crop of the temperate regions and is not cultivated in the hottest areas of the globe. In semi-tropical countries like India, it is only grown in the cold season and experience proves that the sowing time of wheat is largely regulated by the soil temperature.

3. The Influence of Rainfall and Temperature on Growth.

Rainfall. The climatic factors which have the greatest effect on the yield of wheat in India are unquestionably the amount and distribution of the rainfall. Within limits, the distribution of the rain is more important than its amount. Provided the subsoil is fairly moist, late September and early October rains are the most significant as they not only supply moisture for the final preparations and for germination but also cool the seed-bed sufficiently for the young crop to thrive. On the other hand, a heavy monsoon ending in late August or early September which is not followed by the sowing rains is generally unfavourable for wheat in alluvial tracts like Bihar and Oudh, and in black soil areas like Bundelkhand and the Central Provinces. In the former case in such seasons, the soil is almost certain to be on the warm side at sowing time, while in the latter there may be insufficient surface moisture for germination.

After sowing is completed, the first rains, known as the Christmas rains, generally fall towards the end of December or during January. These are, on the whole, light and well-distributed and, as is well known, originate from depressions which pass over India from the direction of Persia and Mesopotamia. It is rare for rain to fall during November and early December. The Christmas rains are exceedingly beneficial to the wheat crop. They not only moisten the soil but check any tendency for the ground to get too warm. Generally speaking, they serve definitely to establish the cold weather which is so important for the well-being of *rabi* crops. These winter rains, however, are often delayed and may not appear till late in February or even in March when their influence on the yield of the wheat crop is small and may even be distinctly harmful, particularly when heavy falls occur after the wheat is in ear. Except in the extreme North-West, such rain is too late to exercise its full effect on the growth while the formation of surface crusts interferes with the aeration of the soil and tends to help in producing those conditions which bring on rust attacks. Rain and moist weather when the crop is ripe easily set up sprouting in the ear as the temperature is usually high at this period. Showers

during the threshing period cause a little damage from a similar cause, but the people are very clever in protecting their grain heaps and it is rare to find that the moisture penetrates more than an inch or two. In estimating the effect of the rainfall on a wheat crop the distribution rather than the total amount is important. Late September and early October falls are the most valuable of all while early, well-distributed Christmas rains, not exceeding two inches in amount, follow next in order. Late rains, if heavy and long-continued, are decidedly harmful by preventing maturation and by producing rust. A heavy monsoon ceasing early leaves the soil and subsoil too hot for wheat in the warmer wheat tracts of the country.

Temperature. After the distribution of the rainfall, the soil temperature is perhaps the next most important meteorological factor in the growth of Indian wheat. If sown too early before the soil and subsoil have cooled down sufficiently, the wheat seedlings wither and are eaten up by white ants (Termites).[1] When sown at the proper time, however, when the soil and subsoil have cooled sufficiently, the seedlings thrive and white ants do not trouble the crop. Experience shows that the dying off of the young crop is particularly widespread in Bihar and Oudh in years when the total monsoon rainfall is large, when the rains cease early and when the sowing rains (*hathia*) fail. In such seasons, the soil is charged with large quantities of warm water and cooling is slow on account of the mass of water involved and the necessity of keeping the soil closed down to prevent too much evaporation. Such soil conditions occurred in Bihar in 1914 and again in 1915, and whenever they do it is interesting to note that the *ryots* always sow too early and often lose their wheat entirely particularly on the heavier lands which hold the most moisture and presumably cool down more slowly than the drier, higher-lying fields. The remedy for this

[1] It is an interesting fact that in such cases the wheat always germinates well and for a few days shows great promise. This is probably due to the temporary cooling of the surface soil by the evaporation of moisture during the final preparation for sowing. As soon, however, as the roots reach the warmer subsoil, decay sets in and the seedlings begin to wither. At this stage, they offer attractions to white ants which seem to be the consequence rather than the cause of the damage to wheat at this period.

trouble in such seasons in North Bihar is to postpone sowing till the end of October and to cool the soil by evaporation by allowing the furrows to remain open to the sun and air for two or three days according to the amount of moisture present. When this is done, there is much less trouble on account of a hot seed-bed and white ants do little or no damage.

So far, little has been done in tracing the connection between the temperature of the soil in the plains at sowing time and the distribution of the rainfall. The subject is being investigated in the Botanical Section at Pusa and the results will be published in due course. It is fortunate, however, that one series of Bihar soil temperatures is on record which bear on this point. These were taken by Mr. H. M. Leake at Pemberandah during the period March 10th 1903, to March 3rd 1904, and are published in detail in the account of the research work on indigo carried out at Dalsing Serai during 1903 and 1904 by Messrs. Bloxam and Leake. These observations were made thrice daily at 8 A.M., 1 or 2 P.M. and at sunset. The spot selected was the middle of an exposed area of high, light land which was kept free from weeds. The weekly average temperatures at a depth of four inches at mid-day (1 to 2 P.M.) are given in the following table in which the rainfall is also recorded :—

TABLE I.

Soil temperatures and rainfall at Pemberandah.

Period	Average temp. (4″ deep at 1 or 2 P.M., in degrees Centigrade)	Rainfall (in inches)
Sep. 2— 8	30·4	1·4
9—15	30·5	1·0
16—22	30·4	0·1
23—29	29·7	0·6
30—Oct. 6	29·1	2·6 Including 1·6 inches on Oct. 6th.
Oct 7—13	28·0	0·8
14—20	25·0	
21—27	24·9	
28—Nov. 3	22·9	
Nov. 4—10	21·3	
11—17	19·8	
18—24	20·0	
25—Dec. 1	18·7	
Dec. 2— 8	16·5	
9—15	15·8	
16—22	14·4	
23—29	15·2	
30—31	13·1	

It will be observed that there is a rapid fall in the weekly averages after October 20th and that during the succeeding fortnight the temperature fell more than five degrees. The daily temperatures (at a depth of 4 inches and at 1 or 2 P.M.) during this period are given in Table II.

TABLE II.

Daily temperature readings at Pemberandah after the sowing rains.

Date	Temperature (Centigrade)	
Oct. 16	29·5	All readings taken at 4″ at 1 to 2 P.M.
17	28·7	
18	28	
19	26	
20	26	
21	26	
22	26	
23	25	
24	24·7	
25	24·5	
26	24·5	
27	24	
28	23·5	
29	23	
30	23	
31	22	
Nov. 1	...	
2	23·5	
3	22·5	

The fall in temperature from the middle to the end of October is fairly continuous and amounts to 7°·5 C.

Wheat sown in such a season on October 16th would probably have died out while sowings made during the last week of the month would have developed rapidly without a check. In such years when the *hathia* is received, there is often a marked change in the character of the weather about October 20th, the air feels fresher and westerly breezes set in. When these have been blowing for a week or so and the cold season appears to be well established, wheat can be sown without risk. The subject, however, needs more detailed study and the wind velocity, wind direction as well as the humidity of the air should be recorded. The temperature observations on low-lying fields containing much moisture should also be compared with those simultaneously obtained on high-lying, lighter and drier land. These meteorological observations should then be correlated with the extent of root-development and

with the general above-ground growth of the wheat crop. It is certain that, when the seed-bed remains on the warm side, the root-development is poor and the plants begin to shoot prematurely. This tendency is perhaps even more pronounced in the case of *sarson* (*Brassica campestris*) and yellow flowered tobacco (*Nicotiana rustica*) than in the case of wheat. Either of these two crops could be used as living thermometers whose indications would supplement those of the ordinary instrument.

4. Some Practical Applications.

There are at least two directions in which the ideas in this paper can be made use of for practical ends. One relates to the duty of irrigation water in the warmer wheat tracts of India and the other to the improvement of crop forecasts.

Irrigation. The provision of moisture for crops is considered to be the object of all schemes of irrigation. It is more than probable, however, that artificial watering serves another purpose in the case of *rabi* crops, namely, the cooling of the soil to enable vigorous root-development to take place. This being so, the possibilities of the extended use of irrigation water in tracts like South Bihar, the Central Provinces and Bundelkhand ought to be re-considered. It might pay to construct tanks (reservoirs) in these areas solely for the purpose of watering land once in October prior to sowing. This irrigation would cool the land, would give plenty of moisture for germination which, under judicious management, would carry the crop through to harvest. In the case of well irrigation in certain parts of Oudh, there appears to be, on the stiffer soils, an opening for wheat growing with a single watering applied in November followed by the sowing of a rapidly maturing wheat like Pusa 4.

Crop Forecasts. Although the methods adopted in the preparation of crop forecasts in India are a great advance on those previously in use, nevertheless the application of physiological ideas would lead to a still higher degree of accuracy. In framing the first wheat forecast, the distribution of rainfall after the middle of September, the mean air temperature during October and the direction of the wind in the Gangetic plain should receive particular

attention. The root-development and the foundation, as it were, of the crop depend on these factors. In the second forecast, the distribution of the winter rains and the general air temperatures during December and January are significant. Light, well-distributed rainfall, low temperatures and clear, bright weather during the vegetative period are the factors on which the future yield depends. Long spells of abnormal hot weather during this phase or very heavy rains are sure to be harmful. In the final forecast, two things are important—the rainfall and temperature during the ripening period and the manner in which the ears ripen. Anything more than the lightest rainfall during the period of maturation is harmful and temperatures above the average are inimical to a high yield. The appearance of the ears from the time the grain is half ripe till the harvest is perhaps more important than any other indication in estimating the final yield. For a full crop there is a characteristic development in the shape of the spikelets and in the colour of the straw and ears which cannot be mistaken. When half ripe, the spikelets bulge considerably due to the swelling of the middle grain and the ear assumes an uneven, turgid condition. The straw and chaff have a bright healthy appearance which is continued till the crop is ripe. The contrast between this condition and the look of a low-yielding crop is very marked. In the latter case, the ears remain narrow, the spikelets are regular, the ears and straw appear lifeless and the full colour of the chaff is not developed. The range between these two conditions is, of course, great and amounts to at least five maunds an acre. In the United Provinces in 1915, when the conditions for ripening were exceedingly unfavourable and the forecasts of outturn proved to be optimistic, the yield would have been reduced by five maunds to the acre had the appearance of the ripening ears been taken into account. The 1916 crops in parts of Bihar, on the other hand, should have been increased an equal amount. A ripening factor, which can best be judged by the officers of the Agricultural Department and which need only be determined in each of the chief wheat-growing tracts of a Province would be most useful in correcting the ordinary estimates of area and yield sent in by the Revenue authorities.

SUGARCANE CULTIVATION IN NON-TROPICAL PARTS OF INDIA.

BY

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We are led to write this article in response to the following criticism published in *Commerce* of Calcutta, dated 4th May, 1916:—

"The wonderful progress made in sugar-beet cultivation in Europe and cane cultivation in Hawaii, Mauritius, Java, Cuba, and Louisiana, show what science, higher education, and common sense can do for an industry. We in India are still waiting for the Agricultural Department to show us if any possible advantage can be derived from the experimental work carried on by the officials in their effort to solve what seems to be an almost hopeless task. The possibility of improving sugarcane cultivation in Bombay, the Central Provinces, Bengal, Assam, and South India we realize: but what the Agricultural Department expects to do for cane in Bihar, the United Provinces, and the Punjab is beyond our comprehension. We are led to these reflections because we recognize the scope for improving cane grown within the sugar belt and we therefore see no necessity for the department to waste their energy on this cultivation in the United Provinces and the Punjab, where cane cannot be grown satisfactorily owing to adverse climatic and soil conditions. That the climate in the United Provinces and the Punjab is not suitable to sugarcane is a recognized fact; and consequently, we cannot include these in the sugar belt of India. Parts of Bengal, Assam, the Central Provinces, Bombay, and Madras are within the sugar belt we know; that the soil and climate in Bihar is not suitable for cane we also know. Why does the Agricultural Department then employ time and labour on research work for securing

cold-resisting canes with early maturing tendencies, when there is an ample scope for expansion and improvement in provinces within the sugar belt? Although plants can to a certain extent adapt themselves and be domesticated outside their climatic belt the fact remains that their cultivation never really becomes a commercial success, but will always remain an uncertain proposition. With sugarcane this has been borne out time and again and for additional proof we need only compare the yield obtained in the provinces of India such as Bombay, the Central Provinces, and Bengal against Bihar and the United Provinces. In Queensland the cane is grown with uncertain prospects as far south as Nambour, 60 miles north of Brisbane. Cane is grown to a small extent in New South Wales but not successfully. In the Southern States of the United States of America cane has been and still is grown on a small scale as far north as Georgia, Mississippi and Texas. In the last State they even tried to grow cane in the 'Pan Handle' of Texas; but these attempts have not been successful and yet people persist in its cultivation. We could quote a number of other countries where certain climatic and soil conditions have created crop belts, all attempts to improve the types of so-called domesticated crops having failed. These matters could possibly be settled with adequate research work, but it takes a high order of ability and time and money to accomplish anything in this direction, and when the work is completed by the department private resources to carry the scheme further on industrial lines will be necessary. In order that India should become independent of Java sugar the sooner the Agricultural Department turns its attention to the expansion and improvement of cane cultivation in areas within the sugar belt, the greater the possibilities for India to arrive at the necessary state of independence from foreign imports."

On this the *International Sugar Journal*, June 1916, writes as under:—

"*Indian Sugarcane Cultivation.* A Calcutta contemporary, *Commerce*, takes occasion to criticize the Department of Agriculture of India for its policy in devoting its energy to experimental cane work in those provinces of India which it declares are outside the

sugar belt and therefore are quite unsuitable for sugarcane cultivation. These provinces are Bihar, the United Provinces, and the Punjab, and it seems to be concluded in competent circles in India that in them cane cannot be grown satisfactorily owing to adverse climatic and soil conditions. It is therefore asked why the Agricultural Department should employ time and labour on research work for securing cold-resisting canes with early maturing tendencies, when there is ample scope for expansion and improvement in provinces within the sugar belt, such as in Bombay, the Central Provinces, Bengal, Assam, and South India? Our contemporary in fact states that they in India are still waiting for the Agricultural Department to show them if any possible advantage can be derived from such a hopeless policy; and it strengthens its criticism by pointing out that, although plants can to a certain extent adapt themselves and be domesticated outside their climatic belt, the fact remains that their cultivation there never really becomes a commercial success, but will always remain an uncertain proposition. It is possible that the authorities will reply that they have introduced the experiments where they have found that the native population was accustomed to cane cultivation and will take more or less kindly to schemes of amelioration. But it is a fundamental necessity that the soil and climate should be suited to the plant, and if, as *Commerce* claims, the soil and climate of the cited provinces are not suitable, then it does indeed seem a pity to waste time and money on experiments which will certainly not produce any commercial success or assist materially in making India more independent of the supplies of Java sugar. Better concentrate attention and energy on lands within the recognized sugar belt. But we should like to have the official explanation of the policy thus criticized."

On reading these, the first idea that strikes us is that the writer of the article in *Commerce* has completely lost sight of the main point in connection with the Indian sugar industry that the problem in India is a dual one. The word sugar does not solely refer to the refined article which is an obsession firmly fixed in the minds of so many. There are two methods of utilizing the sugarcane when

crushed, namely, *A* the production of *gur* for eating and *B* the production of refined sugar either (i) direct from the cane, or (ii) from *gur*. India's production of sugar (mostly raw sugar) excluding that in Native States is close on 3 million tons of which about 16,000 tons only are exported, the rest is all consumed in the country. Over and above this she has to import over 800,000 tons of refined sugar mostly from Java and Mauritius to meet the continually expanding demand for this kind of sugar. She is therefore far and away the greatest producer and consumer of sugar (raw) in the world, and I would ask what country can possibly supply her with such an enormous quantity. Now the points to be borne in mind are (1) that the vast majority of the Indian population prefer *gur* which is as nutritious as sugar, or rather more so, and (2) that *gur* also enters into many Indian food preparations and there is no likelihood of the demand for *gur* falling off in the near future. On the contrary, the increase in wages and the rise in the price of agricultural produce have enabled certain classes of the labouring and agricultural population to increase their consumption of this commodity. Again, as none of the other sugar-producing countries produce *gur* it must be manufactured within the country itself, for it would not pay to produce it abroad. These being the peculiar conditions we can now proceed to examine how far the tropical parts of India, which are more suited to cane growing, can meet this huge demand. If we refer to the total area under cane in India, we find that about 90 per cent. of the acreage is in Northern and North-Eastern India, *i.e.*, United Provinces, Punjab, Bihar, Bengal, and Assam. Not more than 10 per cent. is in Peninsular India or what may be called the *sugar belt*. It will thus at once be seen that Bombay, Madras, and the Central Provinces cannot possibly supply the total quantity of *gur* required by India. Doubtless it may be asked why not, if there is a market and the land is suitable for cane ? But there are these restrictions. Extension of cane cultivation in these parts is limited by the supply of water, the competition of paddy and such other food crops, and, what is so frequently lost sight of in improving and increasing areas under a particular crop, the economic balance which must be kept level; for unless the price of food is to rise in the district,

the ratio between food and money crops must be kept in that state of balance, which will keep food at its lowest and yet allow the district to grow the greatest amount of money crops available, and it will generally be found that the district has calculated this to a nicety. Canal irrigation is very limited in Peninsular India and irrigation from wells has to be resorted to. This is an uncertain and costly method, and so there is no great extension of area to be looked for in these parts save where new canals are opened. This fact has led districts out of the sugar belt to grow their own cane, for the limiting of the area in the sugar belt would have the effect of forcing up the price of sugar if the demand was great from all other parts of India.

Another reason for their cultivation out of the belt is that cane as a commercial crop is more paying than rice, wheat, or cotton, always provided the necessary labour and water are available and that the cultivator and his family do most of the labour. The following average values of crops in India will make this point clear.

Jute	Rs. 145 per acre.
Sugarcane	Rs. 127 per acre.
Rice	Rs. 52 per acre.
Wheat	Rs. 36 per acre.
Cotton	Rs. 32 per acre.

It will be argued that sugarcane occupies the land for over a year while the other crops occupy at most six months. To this the reply is that in India cultivation of any crop is taken up after the ryot has considered how much labour and cattle power he has at hand and which he must keep employed throughout the year. The ryot looks to his own immediate necessities first. He therefore plants a variety of crops to safeguard himself against ruin resulting from the failure of rains and sugarcane naturally comes high on the list which is the result of a long chain of circumstances proved and tested by years of experience. India is not a country of capitalist farmers with large landed estates. She is a poor country of which the backbone is the illiterate peasantry. The holdings are uneconomic, being small and scattered. Leaving aside the question of expropriation which is unthinkable we have to make the most of the existing situation.

In Bengal, as shown above, jute is more paying. The date-sugar industry in this province is capable of improvement. Some increase in the area under sugarcane is also possible, but the following proverb current in Eastern Bengal will indicate the ryot's ideas about this crop. "Unless a man has seven sons and twelve grandsons he should not cultivate sugarcane." We do not therefore think there is any prospect of a large extension of area under sugarcane in Bengal. It is true that in Assam there are possibilities for developmen tespecially in Goalpara and Kamrup and Nowgong, but labour in Assam is notoriously deficient and the climate of the country in the rains is not calculated to stimulate the inhabitants to any prolonged physical exertion. Further the waste land suitable for cane cultivation has to be reclaimed, new roads made, and in some places either labour has to be imported or labour-saving machinery, such as steam ploughing tackle, has to be introduced. All this spells capital and it is only large capitalistic concerns that can do all this. Nothing in the way of extension can be hoped for from the comparatively limited areas under cane under the ordinary ryot's conditions and to hypothecate on such a capitalistic basis when dealing with the ryot is to bring your scheme under ridicule. A man who farms on the turn of a rupee can't discern the ultimate money saved by using steam tackle.

Turning to Bihar we can confidently say that if there is any part in India where the development of white sugar manufacture is most promising it is here. Even before the outbreak of war the central factories working in Bihar were a financial success. In some parts of Bihar cane is grown without irrigation. It is true that the out-turn per acre of cane is not high but as the cultivation charges are in the same ratio the crop is a paying one. The *gur* produced in Bihar is of inferior quality suitable only for refining purposes and hence the cultivators are not averse to selling their cane direct to factories. In the opinion of many competent authorities practically the whole of North Bihar is suitable for the growth of cane.

The heavy crops of cane on the Pusa farm where the soil is by no means of the most favourable type in Bihar for the growth of

cane but rather the reverse show what can be done by improved cultural methods. The late Agricultural Adviser to the Government of India was of opinion that by the introduction of an improved cane and improved methods of cultivation in Bihar the production of sugar per acre could be raised to a very much higher figure than it is now, and it is not too much to say that it could be easily doubled. And yet the writer of the article in *Commerce* says the soil is unsuitable in Bihar. We wonder where it is possible to find better, more fertile, and more easily cultivated soil than in Indo-Gangetic alluvium. Its fertility is probably largely due to its water-holding capacity. A crop can exist in it through the hot weather when it would fail in most soils. It is true that the advent of severe cold in November affects the growth of cane and also that the crop is not so heavy as in Java, but this is not so great an evil as to put sugarcane clean out of court. We admit that in Northern India thin reed-like canes are grown. Though the sucrose-content is not very low they have a high proportion of fibre and consequently yield less juice to the mill in single crushing. In other sugar-producing countries thick canes are the rule, giving from 30—40 tons per acre under liberal manurial and cultural treatment. Here the crop does not receive that same amount of attention, and as regards manuring it may almost be said that this nitrogen-loving crop practically goes without it in Northern India. It should, however, be remembered that in Northern India excluding Punjab the average out-turn per acre is never below 15 tons of cane, and the cost of cultivation, etc., does not exceed Rs. 70 as the ryot supplies his own labour and cattle power. The crop is therefore a paying one for him. In favoured localities in Northern India people grow *pounda* canes and they are more profitable, but as a rule they require greater care in cultivation, liberal manuring, and are more liable to disease and also to attacks from jackals, etc., and hence the cultivator who has probably experienced all these set-backs plants thin canes and plays for safety.

Coming specially to the United Provinces which have about 1,300,000 acres under cane it is necessary to emphasize what Mr. Moreland has already pointed out that this crop ensures regular

employment to a large number of labourers at a time when other work is hard to find, and given a good season it enables the cultivator to pay his rent and put something by, or give his family and friends a treat. Further it is the stand-by of the hard-working man, calling for just as much labour as he can put into it, and there is perhaps no other crop which rewards skill and labour to the same degree. Any decline in the cultivation of this crop which usually occupies the superior land should therefore result in the lowering of the standard of agriculture in these provinces; on the contrary, a reasonable extension is eminently desirable in the general interest of the community. After a succession of good years the cane area increases by as much as a quarter of a million acres, and after bad seasons it falls back as much as half a million acres. The area under cane appears to be governed by probable prices and by the economic position of the cultivating classes for the time being, *i.e.*, possession or lack of necessary capital. In short, it acts as a financial barometer of considerable accuracy and delicacy.

It will thus be seen that this crop is of vital importance to the United Provinces. Bengal has its jute as a paying crop, Bihar its indigo or tobacco, but the United Provinces have nothing between cane and far less remunerative crops. It is therefore not a question of a few central factories or a small class of consumers, but affects the welfare of a very large part of the rural population. And as at the outside only ⅕th of the total production of the United Provinces is converted into sugar it cannot be said that the cultivators are losing over this crop. In fact those parts of the United Provinces like the Meerut Division which export *gur* show an increase in cane cultivation. It is only parts like Rohilkhand which used to export a large quantity of country refined sugar that have felt the competition of the foreign product and shown a decrease in the area under cane. It may be argued that this extensive cultivation of cane in the United Provinces is due to irrigation facilities. We admit that facilities for cheap irrigation have been greater in the United Provinces than in other parts, but so long as no equally paying crop can be substituted the ryots are wise in cultivating cane and the Agricultural Department equally so in trying to

ascertain whether it can help the ryots in increasing their yield of stripped cane per acre or in improving their methods of *gur* manufacture. In fact, while the cultivators hardly get more than 15 tons of cane per acre, on Experiment Stations 22 to 25 tons of sugarcane of a purity of 85 have been obtained. This variation in out-turns indicates vast possibilities of improvement. Already Mr. Clarke has got a type of cane J. 33 which is far better than any *desi* variety at present grown by the ryots. Not only is there no question of the crop being given up in the United Provinces, but there is a possibility of extended area coming under cane as the result of gradual extinction of poppy cultivation.

The Punjab has nearly 15 per cent. of the total area under cane in India. With the increasing popularity of wheat and cotton in this province, there is no substantial increase in the area under cane, taking the province as a whole. While there is a slight tendency to decrease of area in the older districts some expansion has taken place in the new canal colonies, and if it were not for the scarcity of labour and of manure the increase would probably have been greater. It is true that the climate of Punjab is a very severe one in winter and tests the hardihood and vitality of plants to the utmost, and it is especially trying to sugarcane; still in districts with a fairly plentiful and secure supply of water in some form or other its cultivation is relatively important. The question may naturally be asked why this should be so? We have already explained the general conditions which induce the ryots to take up the cultivation of this crop. The province is not able to meet its own demand of *gur* fully, and as it is far removed from the sea-coast foreign sugar has to stand heavy freight charges which acts as some sort of protection. Though the out-turns are low the cultivators will not give up the crop so long as it is paying to them. The ryot is not a capitalist or a specialist with a large capital on hand anxicus to increase his profits every year. He is satisfied if a crop provides labour for himself or his family all the year round and leaves some net profit.

We think we have written enough to show that in the rural economy of Northern India this crop plays a very important part,

and hence the Agricultural Department is bound to study the crop with a view to suggesting improvements. As Dr. Barber, the Government Sugarcane Expert, has pointed out we want better, richer canes with larger out-turn in the field, greater resistance to disease, and yet adaptable to the methods of cultivation adopted by the cultivator. Improvement in the last particular will only be likely to come if the variety of cane provided is more responsive to intensive cultivation. Although one or other of the thick tropical canes have been a success on almost every Government farm where they have been tried there is no doubt that as a whole tropical canes are not suited either to the northern tract or the ryot's method of cultivation in vogue there. The tropical thick canes needing good cultivation and heavy manuring are often useless to him for simple lack of the means to grow them properly. What is needed is a hardier type of cane capable of holding its own with the canes grown under field conditions in Northern India. Such types are not usually available among the canes grown in tropical countries, and the only way to get them is to produce them ourselves. No particular variety will suit all parts of the vast area of the Indo-Gangetic plain. A series of seedlings must therefore be evolved, each one specially fitted for the particular region where it is intended to replace the local kind. There seems only one way in which this can be attempted. In each case the best local kind accustomed for centuries to its peculiarities of climate and treatment should be selected out and crossed with the richer southern varieties so as to combine its resistant properties with the imported richness and bulk. The work is thus complicated in that a series of separate problems have to be solved and a separate series of seedlings evolved for each geographical region.

To conclude: It is clear from the above that so long as India requires *gur* in large quantities and refined sugar only in comparatively smaller ones we are not justified in saying that the crop has no right to exist in non-tropical parts. It is only these parts that are able to supply the enormous demand for this commodity, and as cane cultivation is profitable to the ryots in these districts as it stands, it is the legitimate function of the Departments of

Agriculture to institute experiments with a view to find out whether any better varieties can be substituted, or whether any improvements in the cultivator's methods of cultivation and *gur* manufacture are possible, and this opens a wide field for study. While the question of *gur* is receiving attention the problem of white sugar manufacture is not being lost sight of. In the Gorakhpur Division of the United Provinces and in Bihar where sugarcane cultivation is concentrated new central factories are springing up. We do not think it necessary to go over the beaten ground and say what experiments have already been made and what improvements effected in this industry in India. It will suffice if we refer the readers to the article on "Indian Sugar Industry", published in the *Agricultural Journal of India*, January 1916, which gives a useful summary of the present position.

To sum up the case in a nut-shell it is this. Cane is grown outside the sugar belt for very good reasons—reasons which have stood the test of years and so are entitled to every respect, and while a crop continues to pay (for there are precious few unpaying items on the ryots' programme) occupies a considerable acreage and supplies a demand, it is not possible to pass it by. It forms a radical part of the district economy, and unless you have another crop equally useful and paying to replace it by, it behoves you to do your best to improve the existing state of things. To fold your hands and say *kuchh parwah nahin* the crop is outside its proper "area," and to split hairs of that kind is to prove the Department completely out of sympathy with the ryots' present wants. No; until it is possible, and I do not think it will ever be so, to replace the cane crop by an effective substitute and to supply the demand for *gur* from other parts—two jobs which will not be done in this century, if ever, it is up to the Agricultural Departments to endeavour to improve the present cane crop. A definite result accomplished now will repay itself a thousand times over in the confidence which it inspires in the ryots for the future. The proverb of "the horse that starved while the grass was growing" is all too true. The ryot wants help now and help that will improve his present state, and a long list of theories may do on paper but are pretty useless for immediate practice. We shall welcome *Commerce's* reply and our columns are open to it.

THE CLASSIFICATION OF INDIGENOUS INDIAN CANES.

BY

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DURING the past two years it has been found impossible to proceed with the classification of Indian canes, commenced in the Memoir[1] describing the varieties collected at the Gurdaspur Farm in the Punjab. This has been due to the urgent need for systematizing the seedling work and placing it on a definite basis. The collection of varieties has, however, proceeded during visits to various parts of India and, although the collection is far from complete, a fairly representative series has been got together. The numbers of plots in the cane-breeding station devoted to varieties at present consist of thick (*Pounda* and introduced) canes 120, thin (Indian) canes 112. At each planting season it has been attempted to place the latter plots together in groups of obvious systematic connection. This has been fairly easy with the main classes, *Mungo, Pansahi, Nargori,* and, to some extent, with *Saretha*, but, besides these, there has accumulated a large number of unclassified forms. Among the latter, it is natural that special attention has been attracted to the two large indigenous cane varieties of South India, *Cheni* and *Naanal*, for from them a number of seedlings have been obtained. During the present cropping season (1916) an attempt has been made to deal with the unclassified series and, although the work was necessarily incomplete and rather hurried, results of considerable interest have already been obtained. It has been demonstrated,

[1] **Barber, C.A. Studies in Indian Sugarcanes, No. 1,** ***Memoirs, Department of Agricu in India, Botanical Series,*** **vol. VII, no. 1.**

namely, that these two South Indian canes have allies in almost every province, even extending to the Punjab, where their analogues may be found in the *Katha* and *Dhaulu* of Gurdaspur respectively recently described in detail.

Naming these two series after the generally best known members, those that have been most widely distributed for trial over the agricultural stations of India, we may speak of *Saretha* and *Sunnabile* groups. Quite a number of the unclassified list have been ranged under these two heads, and full descriptions, drawings, and photographs have been taken of some of them during the recent harvest.

Among those thus dealt with in the *Saretha* group are *Baraukha Ukh* (Cawnpore), *Ganda Cheni* (Mysore), *Chin* or *Chunnee* (Aligarh, Shahjahanpur), *Hullu Kabbu* (Bellary district of Madras), *Jaganathia* (Bihar), *Khari* (Bengal), and *Saretha* (Meerut).

The *Sunnabile* group includes *Bansa* (S. Bihar), *Bansi*, probably the same as *Khadya* (Bombay), *Dhor* (Harrai and Seoni, Central Provinces), *Kaghze* (Aligarh, Pilibhit) *Ketari* (Behta, Bihar ?), *Mojorah* (Assam), *Naanal* (Trichinopoly and Tanjore), *Putli Khajee* (Assam ?), *Rakhra* (Shahjahanpur), and *Sunnabile*, probably the same as *Bansi* (Bombay).

The object of the present note is, firstly, to present a classified list of Indian canes collected in the cane-breeding station, for the use of Provincial Officers, and, secondly, to invite the addition of further varieties which we have not at present obtained. As it is proposed shortly to describe the varieties named above in a Memoir, Provincial Officers are earnestly requested to collect any information that they can regarding the synonyms, distribution, and field characters of these canes, and all such information will be duly acknowledged when describing the varieties.

The following is the preliminary classification of the varieties on the cane-breeding station, with the sources from which they have been obtained :—

(1) *Mungo* group.

Mungo, Sabour.

Paunri, Sabour.

Hemja, Bhikanpore, Sabour.
Buxaria, Sabour.
Burli, Ottur.
Kuswar, Ottur, Partabgarh, Aligarh.
Lewari, Sabour.
Poraya, Sabour.
Matna, Aligarh, Shahjahanpur.
Matna Ukh, Cawnpore.
Rheora, Sabour.
Reori, Partabgarh.
Khatuia, Aligarh.
Agoule 1, Shahjahanpur.
Katara, Barah, Partabgarh.
Ramgol, Partabgarh.
Sarauti, Partabgarh.
Pararia, Aligarh, Shahjahanpur.
Matanvar, Partabgarh.
White Pararia, Shahjahanpur.
Dark Pindaria, Shahjahanpur.
Kharwi, Shahjahanpur.
Patarki Mungo (Partabgarh), Gurdaspur
Matki Mungo, Ottur.

(2) *Saretha* group.

Katha, Gurdaspur.
Lalri, Panipet.
Kansar, Gurdaspur.
Chin, Partabgarh, Aligarh.
Chunnee, Shahjahanpur.
Mesangen, Jullundur.
Saretha, Partabgarh, Jubbulpore.
Dhaur Saretha, Aligarh.
Chynia, Barah.
Baraukha Ukh, Cawnpore.
Jaganathia, Barah.
Ganda Cheni, Mysore.
Khari, Sabour, Jubbulpore.

Hullu Kabbu, Hagari (Bellary District).
Raksi, Shahjahanpur.
Burra Chunnee, Shahjahanpur.
Ramui, Shahjahanpur.

(3) *Sunnabile* group.

Dhaulu of Gurdaspur, Gurdaspur.
Teru, Gurdaspur, Harchowal.
Ekar, Jullundur.
Dhor, Jubbulpore.
Hotte Cheni, Mysore.
Rakhra, Partabgarh, Shahjahanpur.
Kaghze, Aligarh.
Sunnabile (Bombay), Jubbulpore.
Khadya, Manjri.
Bansi (Bombay), Nagpur.
Putli Khajee (Assam ?), Ottur.
Bansa, Sabour.
Ketari, Sabour.
Mojorah, Assam.
Naanal, Tanjore.

(4) *Pansahi* group.

Ketari, Sabour.
Merthi, Aligarh.
Dikchan, Partabgarh.
Sanachi (Dumraon), Gurdaspur.
Yuba (Natal), Pusa.
Chynia, Sabour.
Kahu, Gurdaspur.
Lata, Sabour.
Maneria, Sabour.
Pansahi, Sabour.
Sada Khajee (Assam ?), Ottur.
Bharanga, Shahjahanpur.

(5) *Nargori* group.

Nargori, Sabour.
Kewali, Sabour.

Baraukha, Sabour, Pursa, Shahjahanpur.
Ketari, Sabour.
Chynia, Sabour.
Sararoo, Jubbulpore.
Manga, Shahjahanpur.
Agoule 2, Shahjahanpur.
Kalari, Nagpur.
Katai, Sindewahi.
Mungo (*sic*), Shahjahanpur.
Newra, Shahjahanpur.

(6) Unclassified at present.

Bodi, Gurdaspur.
Dhaur, Aligarh, Shahjahanpur.
Dhaura of Azimgarh, Gurdaspur.
Dhaulu of Phillaur, Phillaur.
Kinar, Aligarh.
Kanara, Jullundur.
Agol (Pilibhit), Partabgarh.
Khagri, Sabour, Dacca, Rajshahi.
Ikri, Pursa.
Khelia, Sabour.
Barhai (Jubbulpore), Gurdaspur.
Barahi, Jubbulpore.
Barokha, Shahjahanpur.
Shakarchynia, Sabour.
Betakali (Dumraon), Gurdaspur.
Kalkya, Manjri.

Many of these varieties have at present been insufficiently studied, being only recently received. There are certain obvious resemblances among the unclassified canes, which may be of use in the framing of new classes or obtaining connecting links between those already instituted. Thus there is little doubt that *Ikri*, *Khelia*, and *Khagri* are closely connected, while *Bodi*, *Betakali*, and *Dhaulu* of *Phillaur* seem to be transitional stages between the *Sunnabile* and *Mungo* groups. The position of others is not yet very clearly defined. Thus *Patarki Mungo* resembles *Bodi* and

Matki Mungo reminds of *Katha*, although both have been included in the *Mungo* group, and so on. But, in the main, the classes show true systematic connection and, in many cases, different names probably refer to the same cane growing in different parts of the country. The localities mentioned do not always indicate the true places where the canes are grown, as most of the varieties have been received from Government farms where collections have been established for the comparison of different forms. Any information which will help to fix the true vernacular names and the exact range of any variety as cultivated will be of special value.

It is to be noted that the lists given above do not include many well known Indian names. Besides obviously *Pounda* canes, such as *Pundia*, *Shamshara*, *Saharanpuri*, *Poovan*, etc., there are such others as *Kajla*, *Vendamukhi*, *Magh*, *Dahlsunder*, *Yerra*, about which some doubt may exist, and the line is sometimes very hard to draw. But the principle has been adopted of excluding all canes about which there is any doubt, and it is quite possible that further study may cause the introduction of some of the thicker canes into the indigenous series, as has recently been the case with *Mojorah*, *Sada Khajee*, and others. In other words, thickness is not the only determining character, and the present classification can in no sense be considered the last word in the matter.

CATTLE POISONING BY *JUAR* (*ANDROPOGON SORGHUM*) AND ITS PREVENTION.*

BY

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AND

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JUAR is a crop which is principally cultivated for fodder in Northern India, and as such the stalks are cut while green, before the ears have formed. It is usually sown in the hot weather before the rains, and in consequence if the rains do not set in early enough the conditions become unfavourable for a good growth and the plants become stunted. Very young plants as well as those which have become stunted, are dangerous to be used as a cattle food, on account of their containing a glucoside which, under certain circumstances, breaks up and yields prussic acid which is a violent poison. The poisonous properties of such *juar* have long been recognized and Watt[1] refers to a prevalent but wrong belief among the Indian cultivators that the poison is the result of an insect which infests the plants when the crop suffers from deficiency of rain. The Indian cultivator, however, could not be blamed for his wrong belief, for even among men of science the true explanation of occasional cattle poisoning by *juar* was not known before 1902, in which year the prussic acid yielding glucoside was discovered.

* Reprinted from the *Agricultural Journal of the Dept. of Agri., Bihar and Orissa*, vol. III, part II.

[1] *Dictionary of Economic Products*, vol. VI.

Owing to unfavourable conditions at the time of planting this year, much *juar* was stunted and many bad cases of cattle poisoning occurred in the villages round Sabour. The first part of June was specially unfavourable for the agriculturists, for the expected showers did not come off and there was a long period of hot and dry weather. The *juar* crops, specially those in high lands, suffered in consequence and there was an accumulation of the poison yielding glucoside in the plants in quantities sufficient to cause fatal effects. As many as nine bullocks died in one village alone, some having strayed into *juar* fields and some having been actually fed with the stunted crop. These deaths were not reported immediately or we should have endeavoured at once to find the quantity of the poison present in the poisoning crop at the time of the death of the animal. In fact ten days passed before we received the information, so that any attempt to estimate the quantity of prussic acid at the time of poisoning was impossible. The weight and constitution of the crop changed very rapidly indeed at that time, and we were therefore compelled merely to estimate the quantities of the poisonous principles in the plants as they stood ten days after they had been found poisonous to cattle. It is likely, however, that at the time of death the quantities existing in the crop were far greater than the amount estimated by us.

The largest quantity of prussic acid that we were able to obtain from the crop of one of the fields where as many as three deaths had taken place was about half a grain per pound of the crop. This quantity may at first sight appear to be small, but when it is considered that only four to five grains of the anhydrous acid in a single dose may be sufficient to cause the death of an ordinary country beast, it is obviously dangerously high. A country bullock will easily eat 30 seers or 60 lb. of *juar* which at the time of our analyses would have contained 30 grains of prussic acid or at least six times the fatal dose. In another field from which no cattle had been fed there was about as much prussic acid as one grain per pound of the crop. Towards the end of June and the beginning of July, there was plenty of rain, the *juar* plants rapidly grew up, and in a few weeks the quantity of prussic acid they were able to furnish, diminished so

much as to be quite harmless. It may strike one as peculiar, that although a large number of goats strayed into the fields and fed upon the *juar* leaves at the same time as the bullocks were dying of poison, yet there was not a single case of mortality among them.

That *juar* is poisonous to cattle in the early stages of its growth and loses its poisonous qualities when it is nearing maturity has long been recognized. We have already said that its poisonous action is due to the presence in the plants of a cyanogenetic glucoside, *i.e.*, a glucoside capable of yielding prussic acid. Glucosides are compounds which on treatment with dilute acids or by the action of unorganised ferments break up into several substances of which glucose (a compound belonging to the sugar group) must be one. Now *Dhurrin*, which is the name given to the glucoside of *juar*, in the same way breaks up into glucose and two other substances of which prussic acid is one. An enzyme or unorganised ferment exists in the plant itself and in presence of water breaks the glucoside up with the result that prussic acid is given out. Dr. Auld [1] maintains that the glucoside itself is not poisonous and that in the animal the saliva and secretions of the stomach have a remarkable effect upon restraining the fermentation of the glucoside, so that an animal may not die, even if it has taken up enough of the pure glucoside. In the case of green *juar*, however, its juices are acid and act in the opposite direction to the saliva and stomach secretions, neutralizing their effects. In consequence it is found that, when the *juar* stalks and leaves are eaten green, fermentation of *Dhurrin* takes place in the stomach itself, and if there is enough of it, the animal dies as a result of prussic acid poisoning. It is possible that immature *juar* if fed with ground chalk would be far less dangerous, as this would neutralize the excessive acidity and prevent the formation of prussic acid.

The amount of *Dhurrin* in *juar* is not constant throughout the life of the crop and changes considerably according to the age of the plants. Climate, weather, and perhaps soil conditions are probably important factors which also determine the change.

[1] *Journal of Agricultural Science*, vol. V, part IV.

Brunnich's[1] experiments in Australia inform us that the glucoside is never wholly absent, but the quantity gradually diminishes from the first stage of growth to maturity. At the earliest stages of its growth the young plant contains a very large quantity of it and as the plant grows up and nears maturity, the cynogen in the glucoside gradually changes into complex nitrogenous compounds or proteins. In the varieties of *juar* that Brunnich experimented with, he found the quantity of prussic acid to be so great that he recommended that *juar* should only be used when the seed ears are well developed, and that it should not be given to animals which have fasted for some time. Willamon and West[2] have found in America that in about two months the available prussic acid under normal conditions is reduced to a harmless quantity. This is confirmed by the common practice in India which is to allow the cattle to feed upon the plants from the time they are two months old until they are nearly mature. In our experiments in a majority of cases we found the amount of prussic acid to be negligibly small in the case of fully grown plants of about eight weeks old. Willamon and West's experiments also tell us, in what part of the plant most of the glucoside is to be expected. In the first three or four weeks of the plant's life, it is concentrated in the stalks; then it rapidly decreases and disappears from there but apparently persists in the leaves in decreasing percentages until maturity. This explains why the goats which strayed into the same fields as the bullocks at the time when the results were fatal to the latter escaped without any harm, because they ate only the leaves which then contained very little of the glucoside while the bullocks ate the whole plants, leaves, stalks and all, and consequently suffered.

It is interesting to note that apparently even under similar conditions of climate and rainfall, the same varieties of *juar* of the same age give widely varying quantities of the poison; that while the crop of one field may be dangerous that of a neighbouring field may be quite innocuous. This is seen from the accompanying

[1] *Journal of Chemical Society*, vol. 83, page 788.

[2] *Journal of Agricultural Research*, 1915, vol. 4, no. 2, page 179.

table which gives the percentages of prussic acid obtained from the crops of three fields of the village of Khankitta near Sabour. It is possible that this is due to difference in the rates of germination, owing to differences in the moisture contents of the soil in which they were planted. This may give rise to a profitable line of investigation. The samples from each of the fields were collected on the same day and the acid estimated :—

Age of the crop when the first sample was taken	Date of collecting the sample	Number of the field	Per cent. of prussic acid	Grains of prussic acid per lb.
1	2	3	4	5
About six weeks ..	3rd July 1915	1	0·0071	0·497
Ditto	Ditto ...	2	0·0045	0·315
Ditto	Ditto ..	3	0·0025	0·175
Ditto	5th July 1915 ...	1	0·0066	0·462
Ditto	Ditto .	2	0·0025	0·175
Ditto	Ditto	3	0·0017	0·119
Ditto	7th July 1915 ..	2	0·0007	0·049
Ditto	Ditto .	3	0·0005	0·035
Ditto	8th July 1915 ...	1	0·0052	0·364

It will be seen that at the age of about six weeks the crops of different fields, apparently similar, could yield materially different amounts of the poison, and though all of them at the time were more or less dangerous, in less than a week, No. 2 and No. 3 had their quantity of poison reduced so much as to be capable of being eaten with impunity. It has not been exactly ascertained under what conditions of cultivation and growth and at what periods, accumulation of the poisonous element in the *juar* becomes greatest. As our attention was drawn to this late in the season when the plants were rapidly losing their poison, no systematic investigation on the subject could be carried out. The American experiments suggest that manuring of a poor soil sometimes results in increasing the amount of the acid in the plant, but certainly there are other factors more important than the soil, which regulate the amount of the poison.

In this season we altogether analysed 25 samples of which seven were from the Sabour Farm and in all cases the farm crops showed considerably less amounts of prussic acid than the outside

ones. This was expected as the farm crops this year were very healthy and were growing vigorously.

What should the cultivator do, if owing to persistent unfavourable conditions his fodder crop does not grow up properly and shows a dangerous amount of the poison ? It is unlikely that sun-drying will be of much use as this process will neither break up the glucoside nor kill the enzyme. In fact it was proved by Brunnich[1] in Australia that sun-drying did not render harmless the poisonous *juar*. As soon as the dry fodder has been soaked in water the enzyme will begin to act upon the glucoside and set the prussic acid free. Instances are not wanting in which the cultivator actually sun-dries a crop which he suspects to be unsafe in the green state, and keeps his dry fodder soaked in water for a considerable time before he feeds his cattle with it. It is just possible that the danger is fairly diminished by this method if sufficient time has been allowed to the enzyme to break up the glucoside entirely, for prussic acid is very volatile and may escape into the air except in so far as it is held in solution by the water present; which at times may be very great. We see therefore that there is a considerable risk in using sun-dried *juar*, firstly, if enough time has not been given to much of the acid to escape, secondly, if there is a good quantity of the acid present in solution after soaking. On the other hand, the process of storing the green fodder in a silo considerably minimizes the danger by breaking up the glucoside, and makes the silage a safe food. This is illustrated by simple experiments conducted in the laboratory at Sabour. The crops of which the prussic acid content had been estimated in the same day were chopped and put under pressure in small drums and were kept in position by lids which were sealed with wax. About three weeks after the lids were opened and the ensilage was analysed and in all cases the quantities of prussic acid obtained were inconsiderably small. That the glucoside was broken up was indicated by distilling the ensilage with water and dilute sulphuric acid, in both of which cases the same amount of prussic acid was

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[1] *Loc. cit.*

obtained. The following tables give the results before and after putting in silo :—

No.	Date of analysis and of putting in silo	Before ensilage		Remarks
		Prussic acid per cent.	Prussic acid in grains per lb.	
1	2	3	4	5
1	14th July 1915	0·0043	0·30	Dangerous.
2	20th July 1915	0·0040	0·28	Ditto.
3	19th July 1915	0·0081	0·57	Very dangerous.

No.	Date of analysis and of opening the silage	After ensilage		Remarks
		Prussic acid per cent.	Prussic acid in grains per lb.	
1	2	3	4	5
1	15th August 1915	0·0001	0·0079	Safe.
2	Ditto	Trace	Trace	Do.
3	Ditto	0·0002	0·0138	Do.

From the above we see that a crop contained on the 14th July 1915 as much as 0·3 grain of the poison per pound of the crop. Only 16 lb. of the stuff is quite sufficient to supply five grains of the acid, the fatal dose for a country cow, while only a month after putting the crop into the silo, the quantity of available prussic acid was only 0·008 grain per pound and 500 to 600 lb. of this stuff will be required to produce fatal effects in a cow.

It appears therefore clear that even stunted *juar* will be perfectly safe when fed to cattle after storing in a silo for a few weeks. It is hoped that we shall take up further experiments on this next year.

HOW TO BOTTLE FRUITS, VEGETABLES, POULTRY, MILK, MEAT, ETC., FOR DOMESTIC AND COMMERCIAL PURPOSES.*

BY

E. L. ROUT,

Inspector of Agriculture, Cuttack.

THE above is the title of a book by ex-Sergeant-Major George Fowler in which are explained in a simple and lucid manner instructions to preserve fruits, vegetables, and other foods in bottles and jars.

Sergeant-Major Fowler has patented special apparatus and bottles for this purpose. When sterilized in this apparatus the above-mentioned articles can be preserved in the vacuum bottles and jars for an indefinite period.

With the kind permission of Mr. James Taylor, Deputy Commissioner of Angul, who has the apparatus and has started preserving with success garden produce of winter vegetables such as peas and beans and has also preserved snipe, the writer is able to furnish this article, with the hope that others who are interested in this work might take it up.

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APPARATUS.

The outfit consists of a bottling apparatus of tin with a thermometer, vacuum bottles, clips and rubber washers or rings, a brush for cleaning the bottles. The thermometer is placed on the side of the apparatus made for holding it in, which is connected with the inside by a passage through which the water

* Reprinted from the *Agricultural Journal of the Dept. of Agri., Bihar and Orissa,* vol. III, part II.

comes in and marks the temperature. The apparatus for heating can be used on an ordinary kitchen or oil stove or a gas burner. The following is a brief description. Full details cannot be given as the system is patented, but instructions accompany the apparatus.

How to sterilize. Put the bottle filled in with fruits or vegetables (cooked or uncooked as the case may be and covered with patent covers with rubber rings) into the apparatus containing water half to three-quarters the height of the bottles. Heat the water slowly to a certain temperature. Now reduce the heating medium and then let the bottles remain in the apparatus at a lower temperature.

If the bottled fruits be intended for commercial purposes the contents of the bottles must not be sterilized at too high a temperature in order to avoid breaking, shrinking and rising of the contents in the bottles which will mar the value of the articles.

Take out the bottles, taking care to keep them on wood or thick paper as the jars might crack in contact with a cold surface such as marble or iron. Keep for 48 hours with the clip or clips on, when they may be taken off or used for other bottles. If the bottles are hermetically sealed the covers should be fast on them, if not then the cause should be rectified and the sterilization repeated.

An unsuccessful sterilization would cause air to get in and ferment the stuff in 18 to 36 hours or become mouldy in a few weeks. If all the germs contained, in the fruit, vegetable or meat, etc., have not been destroyed by sterilization although the bottles are found to be sealed hermetically fermentation will occur and gases collect within the bottles.

The secret of bottling is the thorough sterilization of the articles, on which depends the destruction by heat of every germ in the water and contents within the bottles and the exclusion of air during the process when hermetical closure of the lid is caused by the air being exhausted from the bottles during the heating. To ensure a more perfect vacuum the cover should be on the apparatus.

As both cooked and uncooked articles are preserved the process for each of the methods is slightly different.

For bottling cooked vegetables a high temperature is absolutely necessary. The vegetables must be freshly gathered, prepared, washed in salt and water and cooked (for peas and beans boiling is done for two or three minutes only). Then they are dipped in cold water for a few seconds before being put into the bottles. The bottles must be washed beforehand and put into three-quarter ounce of salt. Fill them with cold water and close them with cover and clip (not using the rubber washers or rings). Add salt to the water in the sterilizing apparatus from 1 lb., 2 lb., 3 lb. according to the size of sterilizing apparatus. After sterilizing for the first time for two hours at a high temperature it should be continued again at an interval of 48 hours at a lower one. The clips should not be removed after 48 hours have elapsed after the second sterilization. Thus the vegetables are bottled and kept for use.

The cost of the apparatus varies from 20*s*. to 50*s*., including a number of bottles, and can be had of Geo. Fowler & Co., 72, Queen's Road, Reading, England.

In India, where there is so often a superfluity of fruit and vegetables at one season of the year and total absence at another, the advantage of bottling surplus produce is evident.

AGRICULTURAL AND VETERINARY OFFICERS ON MILITARY DUTY.

THE following Officers of the Agricultural and Veterinary Departments are serving with His Majesty's forces for the period of the war. Any further particulars as to their movements, transfers, etc., will be published here if notified to the editor.

Name	Designation	Particulars regarding service
IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA.		
Major J. W. Leather, V.D., F.I.C.	Lately Imperial Agricultural Chemist, Pusa.	Joined the Army in England. A Major in the 3rd Garrison Battalion of the Cheshire Regiment.
J. H. Walton, B.A., B.Sc. ...	Supernumerary Agricultural Bacteriologist, Pusa.	Joined the Indian Army Reserve of Officers on 4th June, 1915, on active service in Mesopotamia.
S. N. Mitra ...	Assistant, Mycological Section, Pusa.	Joined the Military Service on 6th July, 1916, as Indian Warrant Officer, to help Captain C. F. C. Beeson in dealing with the fly nuisance in Mesopotamia.
P. G. Patel ...	Assistant, Pathological Entomological Section, Pusa.	Ditto.
H. N. Sharma, B.A. ...	Ditto ...	Ditto.
L. S. Joseph, G.B.V.C. ...	Veterinary Assistant, Pusa.	Ditto.
P. C. Kar ...	Fieldman, Mycological Section, Pusa.	Ditto.
T. V. V. Subramania Aiyer.	Typist, Entomological Section, Pusa.	Ditto.
P. Narayanan ...	Artist, Publication Branch, Pusa.	Ditto.
D. P. Singh ...	Fieldman, Pathological Entomological Section, Pusa.	Ditto.
IMPERIAL BACTERIOLOGICAL LABORATORY, MUKTESAR.		
R. V. Norris, M.Sc. (Manch.), F.I.C., D.Sc. (London)	Physiological Chemist, Imperial Bacteriological Laboratory, Muktesar.	Joined the Military Department on the 7th of October, 1915; now on active service in Mesopotamia as Second Lieutenant, I. A. R. O., attached to 112th Mahratta Infantry.
G. H. K. Macalister, M.A., B.C., M.D., D.P.H., M.R.C.S., L.R.C.P.	Pathologist, Imperial Bacteriological Laboratory, Muktesar.	Permitted to apply for active service under the Director-General, Indian Medical Service.

Name	Designation	Particulars regarding service
BENGAL.		
K. McLean, B.Sc. (Edin.) ..	Deputy Director of Agriculture, Dacca.	Has already applied to join the Indian Army Reserve of Officers.
A. D. MacGregor, M.R.C.V.S.	Officiating Superintendent, Indian Civil Veterinary Department.	Posted to Meerut on the 18th February, 1916.
P. J. Kerr, M.R.C.V.S. ...	Superintendent, Indian Civil Veterinary Department.	Serving with Expeditionary Force, D. No. 9, Field Veterinary Section, with effect from 10th July, 1915.
Nalinakshya Basu ...	Veterinary Assistant ...	Serving in 45 Corps, Ambala Cantonment, from 14th May, 1916.
Nagendra Nath Banerjee ...	Ditto ...	Serving in 47 Corps, Lahore Cantonment, from 21st May, 1916.
Bidhu Bhusan Sen ...	Ditto ...	Officer in charge Transport Corps, Lucknow, from 9th May, 1916.
Jitendra Nath Sen Gupta	Ditto	Officer in charge Transport Corps, Lucknow, from 15th May, 1916.
Khagendra Nath Ghosh ..	Ditto ...	Serving in 71 Camel Corps, Ferozepore, from 2nd June, 1916.
Sailendra Lal Sen ...	Ditto ...	Serving in 16 Grantee Camel Corps, Rawalpindi, from 14th June, 1916.
Jagman Singh ...	Ditto ...	Serving in 33-Cavalry Depôt, Saugor, from 20th May, 1916.
BIHAR AND ORISSA.		
E. J. Woodhouse, M.A., F.L.S.	Economic Botanist and Principal, Sabour Agricultural College.	Joined the Indian Army Reserve of Officers on 14th March, 1915, serving as Lieutenant, Central India Horse, I. E. F. "A."
N. S. McGowan, Diploma in Agriculture (Cantab.)	Professor of Agriculture, Sabour.	Joined the Indian Army Reserve of Officers on 8th March, 1915, served as Second-Lieutenant, 53rd Sikhs, I. E. F. "E." Wounded in action and is in hospital.
UNITED PROVINCES.		
A. E. Parr, Ph.D., M.A., B.Sc., M.S. ...	Deputy Director of Agriculture, Aligarh.	Attached to 11th Cavalry, with effect from 31st August, 1915.
R. D. Fordham ...	Garden Overseer ...	Attached to Indian Expeditionary Force "B," South Africa.
W. S. Smith ...	Ditto ...	Ditto.
T. S. Davies ...	Deputy Superintendent, Indian Civil Veterinary Department.	Private Anglo-Indian Force attached to 1st South Lancashire Regiment, Quetta.
M. Sadiq Husain ...	Veterinary Assistant ...	27th Mule Corps, Peshawar.
Sirdar Jogendra Singh ...	Ditto ...	3rd Skinner's Horse, Bareilly.
Sirdar Kehar Singh ...	Ditto ...	16th Cavalry, Lucknow.

Name	Designation	Particulars regarding service
	United Provinces—contd.	
Sirdar Murat Singh ...	Veterinary Assistant ...	34th Prince Albert Victor's Own Poona Horse, Ambala.
Sirdar Niranjan Singh ...	Ditto ...	36th Jacob's Horse, Ambala.
M. Bashir Mohamed Khan	Ditto ...	38th King George's Own Central India Horse, Agar.
Sirdar Nand Singh ...	Ditto ..	41st Mule Corps, Sialkot.
M. Abdul Rahman ...	Ditto ...	46th Mule Corps, Rawalpindi.
Rai Kedar Nath ...	Ditto ...	17th Mule Corps, Bannu.
Munshi Rahat Husain ...	Ditto ...	49th Mule Cadre, Lahore.
	PUNJAB.	
H. Southern, M.A. ...	Deputy Director of Agriculture, Gurdaspur.	Joined the Indian Army Reserve of Officers on the 12th of March, 1915, as Second-Lieutenant, Expeditionary Force. Reported missing in Mesopotamia; unofficially understood to be a prisoner in Turkish hands.
	BOMBAY.	
T. Gilbert, B.A. (Cantab.), Diploma in Agriculture (Cantab.)	Deputy Director of Agriculture, Southern Division, Dharwar.	Has already applied to join the Indian Army Reserve of Officers.
E. S. Farbrother, M.R.C.V.S.	Veterinary Officer attached to the Office of the Superintendent, Civil Veterinary Department, Sind, Baluchistan and Rajputana.	Ditto.
	MADRAS.	
E. Ballard, B.A., F.E.S. ...	Government Entomologist	Joined the Army in England with effect from 12th February, 1916; serving in Royal Field Artillery.
W. J. D'Costa ...	Veterinary Inspector ...	Joined the Army on the 5th of November, 1914; Veterinary Inspector attached to No. 10, Field Veterinary Section, Indian Expeditionary Force "D."
S. C. Jeyasingh Raj ...	Veterinary Assistant ...	Served in the Military Department from 25th November, 1914, to 26th January, 1916, when he returned to his original post, being invalided for military duty.
S. R. Lakshman ...	Ditto ...	Serving in the Army Department since 11th May, 1916, as Reserve Veterinary Assistant through the Base Transport Officer, Indian Expeditionary Force "D," Makina Masus.
R. Rajamanikkan Pillai ...	Ditto ...	Serving as Veterinary Assistant, 20th Duncan Horse, Neemuch, from 1st April, 1916.

Name	Designation	Particulars regarding service
CENTRAL PROVINCES.		
J. H. Ritchie, M.A., B.Sc. ...	Deputy Director of Agriculture, Western Circle, Nagpur.	Has already applied to join the Army.
L. M. Roy ...	Veterinary Inspector ...	35th Scinde Horse, Jubbulpore.
Abdul Rahman ...	Ditto ...	Depôt 29th Lancers, Saugor.
Hemraj Singh ...	Veterinary Assistant ...	2nd (Rawalpindi) Division.
Atta Mahomed Khan ...	Ditto ...	Ditto.
D. Mulla Singh ...	Ditto ..	Ditto.
M. A. Gafoor Khan ...	Ditto ..	Ditto.
B S. Pardeshi ...	Ditto ..	Ditto.
Mohan Lal Bali ...	Ditto ...	45th Mule Corps, Ambala.
P S. Nair ...	Ditto .	54th Camel Corps, Lahore Cantonment.
R. K. Patankar ...	Ditto ...	71st Camel Corps, Ferozepore.
Mirza Kurshed Ali Beg ...	Ditto ...	Ditto.
Qazi Minhazuddin ...	Ditto ...	Not yet posted.
ASSAM.		
A. G. Birt, B.Sc. (Durham)	Deputy Director of Agriculture, Assam.	Joined the Indian Army Reserve of Officers on 30th April, 1915; attached to the North Staffords Regiment and then transferred to the 87th and 82nd Punjabis. Invalided to India temporarily.
U. Kollington ...	Veterinary Assistant ...	Posted to 3rd (Lahore) Divisional Area; Jullunder.
Suresh Chandra Chanda ...	Ditto ..	Attached to 8th (Lucknow) Division, Lucknow.
BURMA.		
Colonel G. H. Evans, C.I.E., A.D.C., M.R.C.V.S.	Superintendent, Civil Veterinary Department.	Served at Rangoon as Port Defence Volunteer from 5th August, 1914, to 15th January, 1915.
Major T. Rennie, M.R.C.V.S.	Second Superintendent, Civil Veterinary Department.	Ditto.

NOTES.

The Preparation of Indigo Paste. MR. W. A. DAVIS, the newly appointed Indigo Research Chemist, instituted experiments immediately on his arrival in India to ascertain the best methods of preparing indigo paste of standardised indigotin content and of preserving such paste from bacterial change during storage or transport. He has established that there is no real difficulty in preparing an indigo paste containing approximately 20 per cent. indigotin.

A large scale sample of about ½ ton of uniform indigo paste was prepared at the end of July at the Honourable Mr. D. J. Reid's factory at Belsund and this has been sent to England for the dyers to report upon.

Experiment has shown that probably the best method of rendering the indigo paste stable is to make it slightly alkaline during mixing, by adding about 0·5 per cent. of soda ash. Such paste can be kept for months without showing any development of bacteria or change in composition. There will be no difficulty in preparing homogeneous indigo paste provided a suitable mixing machine is installed in the various factories. We await with interest further developments.—[EDITOR.]

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The Improvement of Fodder Production in India. The improvement of cattle in India depends largely on a plentiful supply of good fodder. This fact is now being generally recognized and few people are to be found who believe that any real progress can be made in animal production if the food-supply remains, as at present, a limiting factor. The first step in the problem is to feed the animals which already exist. The creation of new types and the improvement of the present breeds by selection are

matters of secondary importance in so far as the cultivator is concerned.

The increased production of fodder per unit area is one of the subjects which has been taken up at the Quetta Fruit Experiment Station. In order to get the land into condition for fruit and also to provide a cover-crop between the rows of young trees, various annual fodder plants have been tried. Of these, Persian Clover or *shaftal* (*Trifolium resupinatum*) has proved the most satisfactory. This is a rapidly growing annual which can make use of the winter rains and which gives a large amount of fodder, the last crop of which forms an excellent green manure. An account of the cultivation of this crop and of the preparation of clover hay has already been published.[1] In the present note, the best method, so far discovered, of inducing the crop to give the highest yield per acre is dealt with.

Where the irrigation water is limited, as at Quetta, two means of increasing the duty of water in fodder-growing have been found successful. In the first place, crops like *shaftal* grow faster and need less water if the land is manured in the first instance with farm-yard manure at the rate of about fifteen to twenty tons per acre. The manure apparently increases the aeration of the soil for the benefit of the root-nodules and the effect on the land is not lost in subsequent years. Indeed the growth of the *shaftal* improves the fertility and the second year's crop without manure is better than the first. The second method of making the water go further is by the proper grading of the surface so that the irrigation water flows evenly over the land. In such fields, long narrow *kiaris*, about 300′ × 25′, can be watered easily from one end from a well-made, turfed distributary. The expense and trouble in grading and levelling and in the adoption of the most suitable form of *kiari* is well repaid by the amount of water saved, by the ease with which irrigation can be carried out and in the evenness of the resulting crop.

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[1] Clover and Clover hay, *Bulletin no. 5, Fruit Experiment Station, Quetta*, 1915 (reprinted in the *Agricultural Journal of India*, vol. XI, p. 71, 1916).

During the past season, one of the plots at Quetta which was not in very good condition was put down in *shaftal* in August 1915. The land was manured with farm-yard manure at the rate of about 20 tons per acre and sown with *shaftal* under a thin cover-crop of maize. The area of the plot was 0·6735 acre and five cuts were taken as follows :—

		lb.
1. First cut on October 18th, 1915	... ...	1,325
2. Second cut on December 2nd, 1915	... ...	4,185
3. Third cut on March 14th, 1916	... ...	6,040
4. Fourth cut on April 20th, 1916	... ...	12,730
5. Fifth cut on May 19th, 1916	... ...	13,737
Total of five cuts	...	38,017

The last crop, which was about the same as the fourth or fifth in weight, was not harvested as this particular plot was kept for seed. Taking this at 12,000 lb., the total of the six cuts would have amounted to 50,017 lb. of green fodder. This works out at 33·15 tons per acre per annum. At eight annas per 100 lb., the year's produce would be worth Rs. 371 per acre, an income obtained with the minimum expenditure of water and resulting in an increase in fertility. This result, which has been confirmed many times at Quetta, indicates the methods which should be adopted in fodder growing on alluvial soils in India—intensive cultivation combined with the minimum expenditure of irrigation water. It is probable of course that still heavier manuring would give more cuts and more produce per cut. This has not been tried up to the present as the supply of farm-yard manure in the Quetta valley is limited and there is no point in discovering improved methods which cannot possibly be applied.—[A. Howard.]

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A paper on "**Scientific Agriculture in India**" by Mr. James MacKenna, M.A., I.C.S., Agricultural Adviser to the Government of India, and Director, Agricultural Research Institute, Pusa, was read at the meeting of the Royal Society of Arts on 27th April, 1916, by Sir Steyning W. Edgerley, K.C.S.I., K.C.V.O., C.I.E. The paper was much on the lines of his recent monograph on "Agriculture in India." The discussion which followed is published in the

Journal of that Society, Vol. LXIV, No. 3316, June 9, 1916, and is reprinted here as it contains much that is suggestive and illustrates the different points of view which appeal to workers in different lines.

The Chairman (Sir Robert W. Carlyle), in opening the discussion, said the out-turn of rice in India far exceeded that of any country in the world of which we had accurate figures, it being grown over an area which was almost equal to that of Great Britain and Ireland. The production per acre, however, was not at all satisfactory. Compared with countries like Italy and Spain it was very poor, the out-turn in Spain being on the average about five times as great per acre as that in India. In the out-turn of wheat India was second to the United States and Russia, it being grown over an area greater in extent than England. The importation of Indian wheat last year played a great part in preventing an exorbitant rise of prices at a critical period. Here again the production per acre was low, it being barely one-third of the average out-turn in this country. India had the second largest out-turn of cotton in the world, taking second place to the United States. As regards sugarcane, it headed the world. The out-turn per acre was bad, the average in India being about one ton of raw sugar per acre against four times that amount in Java and Hawaii. Thus there was a large margin for improvement in quantity and very often in quality of the crops grown over large areas in India. It was impossible to hope that, within any reasonable number of years, the out-turn of rice or wheat per acre would approach that of Spain or England, but it was possible by scientific agriculture to obtain something very much better than the present meagre results. The author had indicated that it was expected in a few years, owing to one improvement in wheat alone, to make £5,000,000 a year more than at present. That improvement affected only one-sixth of the area under wheat, and it would bring the yield up to about one-half of what it was at present in England. The improvement of agriculture in India was, he believed, the greatest problem now before that country. The Indian agriculturist often did admirable work so far as his means allowed, and by many centuries of experience he

had evolved excellent methods, but their practice could be improved by scientific application. He did not in the least underrate the importance to India of general industrial development. It was very desirable that the proportion of the population entirely dependent on the vicissitudes of the seasons should be diminished ; but the main staple of India must for all time, so far as he could see, be agriculture. The development of agriculture was not only of vital importance to India from the point of view of the economic welfare of the people, but also of very great importance politically. He believed that under Indian conditions, no political development could be altogether sound which had not at its base a prosperous peasantry capable of understanding and taking its full part in the local administration. It was very fortunate that just at the time when, under Lord Curzon's government, the Agricultural Department was put on its present lines, the great co-operative association movement was also developed. He looked to that movement to produce a profound transformation of Indian social conditions. In the ten years that elapsed since it was first really started, 750,000 members had joined the associations, and he had seen in all parts of India the great increase in the well-being and well-living of villages where they flourished. As the author had pointed out, the two directions in which agriculture would greatly benefit by the movement were, firstly, that it enabled the Agricultural Department to deal with bodies of agriculturists instead of with single cultivators ; and, secondly, it enabled the cultivator to borrow money at a rate of interest so low as to enable him to apply capital to the soil with profit. The cultivator had not, so far, availed himself of that privilege to any great extent, but he was sure that there would be rapid development in this direction, and that, owing to the influence of the associations, much more capital would be applied to the soil. India owed a great debt of gratitude to Lord Curzon for his action in regard to agriculture in India. It was very largely owing to the interest that he had taken in the matter, and to his insight into the best methods of furthering it, that the Agricultural Department owed its organization on present lines ; and it was also largely due to him that legislation was passed

which made co-operative associations possible, and which provided the administrative machinery for stimulating the growth of such associations. It was also under Lord Curzon's *régime* that Sir Colin Scott-Moncrieff's committee was appointed which investigated the possibility of developing irrigation in India, and the result of its labours had been that the amount of work done since then on irrigation had enormously increased. All the time he was a Member of Council he never experienced any difficulty in getting money for any irrigation scheme which was ready. The author had shown in his paper a thorough grasp of the problems with which the Indian Agricultural Department had to deal, and he was sure the country would derive great benefit from his knowledge and capacity during his tenure of office as Agricultural Adviser.

Sir H. Evan M. James, K.C.I.E., C.S.I., thought from his experience, going back fifty years, that very great difficulty would be experienced in getting the conservative agriculturists of India to support the Agricultural Department. Fifty years ago there was a great demand for good Indian cotton in consequence of the American War, and a very distinguished Collector, without any assistance from Government, bought up all the seed which he could procure of the best variety then on the market, called Hinginghat, and forced the ryots to sow it. If any ryot sowed any of the old bad indigenous cotton his crop was pulled up. As a result, in the first year the ryots of that district benefited to an incredible extent, owing to the superior value of the new crop. At the conclusion of the American War interest in Indian cotton on the Liverpool cotton market died out, and an Act which had been passed in Bombay to prevent the adulteration and mixing of cotton was, at the instance of the Bombay merchants, repealed. As a result Indian cotton again became a byword in the market; but a fresh attempt was now being made to revive the cultivation of better staples. Unless, however, the Government of India were prepared to go further than merely introducing good staples, by insisting on their being grown and kept pure, all the very benevolent experiments referred to in the paper were, so previous experience proved, likely to prove abortive. The ryot was a very nice fellow, but he was very

conservative; and although undoubtedly a good deal might be done in the way of improving Indian cotton, it was a very long and hard climb uphill to do anything really practical and permanent. Nevertheless, he wished every success to the Department.

Sir Andrew H. L. Fraser, K.C.S.I. (formerly Lieutenant-Governor of Bengal), differed entirely from the remarks made by Sir Evan James, his experience making him an optimist in regard to the future of Indian agriculture. He believed the Indian cultivator was perfectly ready to adopt any method which was actually proved to pay, but it was necessary to show him that something was to be gained by adopting the recommendations of the Department. It was not his experience, especially in later years, that it was difficult to get the ryot to move in the right direction. He was very glad to think that the abominable heresy that an improvement in agriculture could only be obtained through the medium of large capitalist cultivators had now been dispelled. Capital was, of course, necessary; but he would rather give up hope of improvement than see the smaller cultivators swallowed up. The growth year by year of the co-operative system, which had been initiated with so much success, filled him with the greatest belief in the future of Indian agriculture.

Lieutenant-Colonel S. H. Godfrey, C.I.E., Indian Political Department, said that Central India contained many forest tribes which took very reluctantly to agriculture, but which worked very keenly on the development of forest produce. The importance of lac was brought home to him shortly before the war. The Maharaja of Rewah started a lac factory on up-to-date lines in order to develop that very important industry in Central India, and shortly before the war Germans offered to take the whole of its output, which they mixed with cheap German alcohol and exported as varnish. When war broke out the German trade stopped, and the forest tribes were threatened with the elimination of their means of livelihood. Two small States in Central India, in order to rescue their forest tribes, started a scheme to work the factory themselves, which proved successful: and as the markets in Central India for forest produce were limited, a project was submitted to the Government of India

to develop a wider ambit for the Native States which had the various forest tribes depending upon them. It was approved by the Government of India, and the Maharajas of Dattia, Panna, and Chhattarpur, the Rajas of Nagod and Maihar, and the Chaube-Jagirdars of the Baghelkhand Political Agency formed a private limited liability company for the development of the work. Shortly after the beginning of the war, Cawnpore was suffering from the want of tannin; the Chiefs employed a scientific expert to report on their produce, and they discovered they possessed some very valuable tannins which were wanted by the Cawnpore factories for the manufacture of army equipment. The company at present deal with lac, tannin, and hides, and the Maharaja Holkar of Indore had established a factory for the manufacture of vegetable dyes for the replacement of aniline dyes. It was the first co-operative State scheme that had been started in India, and had great possibilities. The Central Indian States covered a very large area, from which it might be possible to obtain acetone by dry distillation, and tannin, the latter of which would go far towards supplying a very sore need at present in India, which had to be met by the importation of wattle bark from countries as distant as South Africa. If encouragement were given to the far-sighted and patriotic Indian Chiefs who had risked their money in the concern, it would not only benefit them and their people, but it would go a long way in the scientific development of other States. The Chief Commissioner of the Central Provinces had signified his approval of the scheme by giving to the company large tracts of forest in the northern portions of the Central Provinces on what was practically a profit-sharing basis, which seemed to show that a responsible official had some belief in the development of Central Indian forest produce on scientific lines. His Majesty's Secretary of State for India had sent a tannin expert to India and Burma with instructions to visit the Native State factory at Maihar, in Central India.

Mr. A. Yusuf Ali, I.C.S. (retired), pointed out that the apparent slowness with which agricultural improvements were introduced into India was not due so much to the unreasonable attitude of the ryots or of the people as to certain conditions which made it difficult

for them to utilize those processes from which they were convinced they could make money. He was an optimist in regard to the improvement of Indian agriculture in the future, but there were four main difficulties in the way of a greater scientific application of improved methods. Firstly, the ryots had very little capital. Although agricultural co-operation had placed within their means the power of combining together and raising capital, it must be recognized that the co-operative credit movement was in its infancy, and as long as rates of interest of 9 and 12 per cent. prevailed it was impossible to speak of the salvation of agriculture in the matter of borrowing capital. The second need of the Indian agriculturist was a better organization not only in regard to the selection and issue of good seed, but in the selling of the produce. The ryot often received far less than his due for his produce, a larger proportion than was equitable going to the middleman. Thirdly, a more favourable fiscal arrangement was required. Many of the by-products of agriculture were not utilized because the ryot sometimes felt that he was handicapped by the Revenue Law. A great deal had been done in recent years in the Northern Provinces in the way of ensuring to the ryot the benefit of any improvements he made, but he did not have as much protection as he should do. The zemindars were also chary in many cases of investing capital in the land, because they found that, in the periodical settlement, they did not always obtain the results which were contemplated under the Revenue Law. An improved Revenue Law in regard to the partition of land was required. Small holdings were sub-divided to such an extent that holdings of less than one acre existed. Such minute sub-division was not necessary, and it would be found in many cases that they were merely paper sub-divisions. It was necessary to insist that in Revenue partitions the holdings should be compact and not scattered about. The most important necessity of all was improved agricultural education, because in his opinion more capital would be forthcoming, better organization would be available, and better fiscal arrangement would be insisted upon when the agriculturist was better educated. Education—the right sort of education—was the crux of the matter, and he would

like to have seen more attention devoted to that subject in the paper.

Sir Frederic S. P. Lely, K.C.S.I., C.I.E., expressed his sense of admiration of the silent but substantial work that had been done in India during the last few years by the Agricultural Department. Compared with earlier days there had been an enormous advance in the manner in which the Government had dealt with the subject.

Mr. J. S. Beresford, C.I.E., said the agricultural conditions in Egypt were very much the same as in India, but there was a great difference in the results obtained and the rentals charged for the land. The difficulty in India was that the cultivator had a very small amount of capital, whereas in Egypt the farmer thought nothing of spending £2 an acre on imported artificial manures, without which the large crops grown could not be produced. He doubly recouped the expenditure by the greater yield. It was impossible for the best production from the land to be obtained without the expenditure of capital, and in any new schemes the Government of India introduced that fact must be borne in mind. It was of interest to mention that since the Agricultural Society of Egypt took in hand the purchase and distribution of artificial manure the consumption had largely increased. The import in 1909 was 21,000 tons, value £178,000 ; while in 1912 it had risen to 70,000 tons, value £668,000. Ninety per cent. of this was nitrate of soda. It was chiefly due to the judicious application of such manure that the high level of production in Egypt was now maintained, for the supply of nitrates from the numerous ruins in the country, on which the people formerly relied, was fast becoming exhausted.

Sir Daniel M. Hamilton, in proposing a hearty vote of thanks to Mr. MacKenna for his admirable paper, thought the last speaker had put his finger on the weak spot in Indian agriculture, *viz.*, the want of finance on the part of the cultivator. It was impossible to build up any industry unless it had a sound system of finance at its foundation. Until the financial question was settled he was afraid Indian agriculture would not advance as rapidly as it should do. He recently read a paper by Mr. Howard calling attention to the fact that the surface soil of India, which was the best part of

the soil, was being washed away. Mr. Howard advocated the erection of irrigation bunds to hold up the soil, but such work could not be carried out without money. So far as manures were concerned, he hoped a trial would be made in India of the bacterialized peat discovered by Professor Bottomley of King's College. It had been proved to be a first-class manure, and was, he understood, being manufactured by the Manchester Corporation at £3 a ton. The Government had recently appointed a Commission to study the question of helping Indian industries. Everything possible should, of course, be done to help manufacturers of every kind, but it was often forgotten that the agricultural population of India must always be the great purchasers of manufactured goods, and it therefore seemed to him that one of the ways in which the industrial development of India could best be helped was to develop her agriculture in every possible way.

Sir Frederic W. R. Fryer, K.C.S.I. (late Lieutenant-Governor of Burma), in seconding the motion, fully endorsed Sir Andrew Fraser's statement in regard to the willingness of the ryot to take up any improvement provided he could be convinced that it would pay him to do so. When he was Deputy Commissioner of Hazara he introduced to the sugarcane growers the iron mill made by Mr. Milne, and they adopted it in preference to their wooden mill, as it could be worked with one bullock instead of two; but they would not use the English plough because it necessitated the use of two men and two bullocks, compared with one man and one bullock with the native plough. The cultivators in India were always ready to adopt any improvements that were visible to their personal observation, and he was certain they would be only too pleased to avail themselves of the services of the Agricultural Department. That Department was evidently doing very good work, and the development of agriculture was, as Lord Curzon perceived, one of the first objects to which the Government should devote its attention.

The Chairman, before putting the motion, said that Sir Evan James's scepticism was not altogether unnatural, as cases had occurred in which the cultivators had thrown away the whole advantage they had gained from selection of seed by adulteration on a

large scale. The Agricultural Department was now fully alive to that danger, and the organization was so good that it was not likely to occur again. He also thoroughly agreed with Sir Daniel Hamilton's remark that finance was of the greatest importance to agriculture.

The resolution of thanks was then put and carried unanimously.

Sir Steyning Edgerley promised that the vote of thanks which had been so heartily passed should, in due course, be communicated to Mr. MacKenna. The suggestion was made in the paper that organized development was begun in Bombay by Mr. Mollison, but he was sure that gentleman would be the first to acknowledge the labours of a Bombay civilian, the late Mr. Edward Ozanne. He went home to Cirencester in 1881, took his M.R.A.C., and on his return to India was appointed in 1883 the first Director of Agriculture in Bombay. Mr. Ozanne did much spade work between 1883 and 1890, and had successfully dealt with the dairy industry, the number of dairies run on scientific lines having been raised from one to about 800 by 1888, if his memory was correct. He thought it would be found that it was because of Mr. Ozanne's success that the business in Bombay outgrew his powers of dealing with it, and it became possible to convince the Government of India that there was a good case for bringing out Mr. Mollison as Superintendent of Experimental Farms in 1890. It remained only for him to express the thanks of the Committee to Sir Robert Carlyle for kindly presiding that afternoon.

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WE quote the following from an article on **Ayrshires in India** printed in the *North British Agriculturist* and reproduced in the *Journal of Dairying and Dairy Farming in India,* Vol. III, Part II.

"The native cattle of India are almost entirely of the humped type. They are very useful and docile cattle in the main, but they are not heavy milkers. They, however, yield very well in butter-fat, the average as a rule being about 4½ per cent. The problem set before Mr. Smith (Assistant Director of Dairy Farms), and his fellow-

workers, therefore, was to find the breed most suitable to cross with these cattle in order to increase quantity, and at the same time not materially reduce the butter-fat yield. The importance of maintaining the butter-fat ratio will be apparent when it is stated that the milk supplied regularly to the Army authorities is expected to average about 5½ per cent. of butter-fat. The way that this is done is to keep attached to each farm a certain number of buffalo cows, and to mix their milk with that of the ordinary cows. The buffalo cow is not a heavy milker, but, like the native Indian cow, she produces a high ratio of butter-fat, the majority indeed giving up to 7½ per cent. A mixture accordingly of two parts cow's milk and one part buffalo's milk usually gives about the desired percentage in the mixed milk. But of course that did not get over the question of increasing the yield of the native cows, and to do this experiments were carried out with Ayrshires, Holsteins, Shorthorns, and one or two other milky breeds. It was interesting to hear from Mr. Smith that of all these the Ayrshire did best. Not only did the imported animals themselves live better than did those of either of the breeds mentioned, but their progeny were generally of a hardier class, while they came consistently more milky. So pleased are the authorities with Ayrshires for this purpose, that they have practically adopted the Ayrshire bull as their crossing animal, some having been imported this year for this purpose alone. We have seen recent photographs of first crosses between Ayrshire bulls and native cows taken on the Government farms in India, and while the animals preserved undoubted indications of their mixed ancestry in slightly dropping ears, and in rather dreamy heads in many cases, they also showed distinct traces of the Ayrshire in their colourings and body formation. Many of the animals are spotted and speckled just as is often seen in a mixed-colour Ayrshire at home, while the drooping quarters of the native cow is nearly always minimized, if it is not entirely eliminated. Mr. Smith is greatly pleased with the result of the cross, and says that already, through its use, it has been possible to increase the average herd yield as compared with the wholly native cow days by something approaching 100 per cent. An interesting feature of the Ayrshire crosses is that there is almost

no trace of the hump of the native cow on them. The excrescence seems to disappear at once, while the crosses are very little short of the native cattle in hardiness and ability to stand the often trying heat. Very fair crosses were got from both the Shorthorn and the Holstein in some cases, but the former especially were inclined to go to beef, and the latter were greatly affected by the climate, many of the original importations dying before full use could be got of them."

In this connection the following facts taken from an article on " An Indian Dairy Farm (New Style) " at Bangalore by Rev. Harold Short published in the same issue of the *Journal of Dairying and Dairy Farming in India* will be read with special interest.

" We inspected some of the Ayrshire bulls, which are imported from Scotland yearly—13 arriving last year—also a few from Australia.

" They have worked a wonderful improvement in the Indian cattle. Crossed with the " Hansi " cow from Delhi, the " Saniwal " from the Punjab or the " Sindi " from Sind district there is an upward result in appearance and milk production.

" The highest price for a country cow is £10 to £20. A half-bred Ayrshire goes for £25 to £40.

" On the first cross the unsightly hump on the shoulders of the native cow and the loose hanging flesh from the neck disappear, the horns are shortened and the whole formation of the animal is broadened and deepened. This improvement has been increased to the third generation. We saw an heifer of 18 months—the oldest of the fourth generation. Its products are awaited with great interest. The crosses have calved at $2\frac{1}{2}$ years, but the country cow knows not the joy of maternity until her fourth year. But the greater value of the cross is shown of course in the milk supply.

" The following 'Comparison Statements' will show the extent of the increase.

" The Saniwal-Ayrshire 'Jill' has shown the common continued increase with each lactation period—her first giving 7,997 lb., the second 8,031, while the third is proceeding as shown below. The calf is always taken away or weaned after seven days.

Comparison Statement of Yields-fat.

6 of the best half-breds.			6 of the best country-breds.		
No. of Cow.	Yields. lb.	Fat. lb.	No. of Cow.	Yields. lb.	Fat. lb.
133	9,450	418·50	18	4,009	200·11
131	7,409	287·48	28	3,858	180·95
138	6,183	248·00	30	3,710	188·70
141	5,217	245·19	22	3,606	176·40
132	5,377	247·34	31	3,400	170·00
127	4,495	184·50	36	3,154	158·00
TOTAL	38,131	1,631·01	TOTAL	21,737	1,074·16
Average	6,355·17	271·83	Average	3,622·83	179·02

6 of the poorest half-breds.			6 of the poorest country-breds.		
No. of Cow.	Yields. lb.	Fat. lb.	No. of Cow.	Yields. lb.	Fat. lb.
290	3,694	166·50	15	1,529	76·45
140	3,628	145·05	7	1,306	62·68
288	3,616	144·66	24	1,233	60·41
135	3,383	137·70	16	1,167	58·35
261	3,349	130·69	21	1,127	52·89
242	2,994	120 00	9	1,047	47 27
TOTAL	20,664	844·60	TOTAL	7,409	358·05
Average	3,444	140·76	Average	1,234·83	59·67 ”

At Pusa also Ayrshire bulls have been imported for crossing with the poorest milkers of the Montgomery herd. The experiments are still in progress but so far as they have gone they promise success.—[EDITOR.]

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Albuminoid Ratio. The albuminoid ratio was first "made" in Germany, and like a good many other German things it was found to be unsuitable for us. The writer long ago pointed out that as these rations were worked out on German animals, with German food, under a German climate, they would require to be greatly modified* to suit us, and he is rather pleased to find that many

* Kellner's famous stock work on the subject "The Scientific Feeding of Animals" was always held by the best British agriculturists to be totally inaccurate regarding its treatment of roots in rations. The truth is, the German never has and never will rightly understand what we mean by 'roots' as he can only deal in sugar-beet and vegetables which hardly rank as cattle food.—[W. S.]

other people have come round to this way of thinking. The first change was made by the Americans, who found that the German figures were quite wrong for America, and drew up a scale for themselves. The reaction has come to us now, and saner ideas are prevailing. To put the matter generally, it is found that a mixture of foods which shows a ratio of one to ten or one to twelve is quite as good as a more concentrated one, but with great many advantages in favour of the lower grade feeding. Thus, instead of using highly nitrogenous foods, like cotton-cake or bean meal, we can use those of a more starchy nature, and thus middlings, maize, rice, and feeds of that class are quite as efficient, while usually costing less in the market. As a matter of fact there is a rough correspondence between the market prices and richness in nitrogen in foods as there is in manures; cakes are nitrogenous, while such things as maize, rice, middlings, etc., are not. All this in practice means that we shall get as good result on a less forcing ratio than we have hitherto used, with a corresponding improvement in the health of the animals. We shall have less milk fever among cows, for instance, on a more starchy food than on one rich in albuminoids. We have taken a long time to find these things out, and probably much harm has been done in past years by following a scheme of using foods in too concentrated a fashion; but it is not too late to alter and improve matters, and to use more of the "weaker" and cheaper foods and less of the "stronger" and dearer ones.—[PRIMROSE McCONNELL. *Journal of Dairying and Dairy Farming in India, Vol. II, Part III.*]

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IN the *Mysore Economic Journal* for May, 1916, there is an interesting note on **Industrial Co-operative Societies** by Mr. Alfred Chatterton. While it is true that in the new development of the material resources of India the industrial co-operative society may possibly play a very important part it must be noted that before this can come about a very large amount of experimental work will have to be done. Hitherto, so far as is known, industrial co-operative societies have not met with any large measure of success, and the work they have undertaken is more of a commercial than

industrial character. Before starting an industrial co-operative society it is necessary that the ground should be prepared by preliminary training, and when machinery is to be set up efforts should be made to enlist the co-operation of surrounding villages so that there may be no shortage of raw material. In view of the amount of training and supervision which these societies require it is not advisable to attempt to increase their number at all rapidly. This will be clear from the description of the two Industrial Co-operative Societies established in the villages of Bannoor and Sabbenahalli in Mysore. These have worked sufficiently long to afford some indication of the difficulties which will have to be overcome before they are completely successful.

The Bannoor Co-operative Society possesses a rice mill and a sugarcane-crushing plant capable of turning out jaggery. The capital of the Society is Rs. 22,500 divided into 150 shares of Rs. 150 each (all of which have been subscribed and on each share Rs. 10 have been paid up). The Mysore Government have advanced the Society a sum of Rs. 20,000 with which to purchase machinery, and the plant has been erected by the Department of Industries. Mr. Chatterton reports that just before the sugar mill was completed the ryots in Bannoor managed to get all their cane milled on the old lines as they were disturbed by rumours regarding the probable success of the new plant. Only 30 maunds of jaggery was made here, but this small quantity has sufficed to dissipate their fears regarding the quality and quantity of the *gur* that can be turned out by the plant. The rice mill with a nominal capacity of 7 cwt. of clean rice per hour has up to date worked for 528¼ hours and has turned out 1,672 *khandies* of clean rice, the milling revenue being Rs. 1,457-11-6. As there was not enough paddy forthcoming the mill was not worked continuously, and even on working days was not worked full time. The people store paddy in their godowns and sell it at favourable times. They believe that paddy when stored keeps much better than rice and so they are unwilling to have it milled. This state of things is, however, changing. The mill is being worked by the Department and the members of the Co-operative Society hardly realize that it is their own property and

that if it is not a success they will have to make good the loss. This will, however, bring them to a realization of the importance of its working full time.

At Sabbenahalli the Co-operative Society has established a cane-crushing plant consisting of a 14 b. h. p. suction gas engine and a 12″ by 18″ roller mill with sufficient evaporating pans of the new type to turn out 250 maunds of jaggery a day. It worked throughout the whole of the last cane-crushing season and successfully dealt with the whole crop in the village. But as the crop in the village was a poor one there was not enough work for the cane-crushing plant. A larger area has been put down under the crop, and if the current season proves favourable it should do extremely well. Here again the members do not realize the nature of the undertaking upon which they have entered. While they appreciate the advantages the question of repayment of the loan does not seriously trouble them.

We quote the following remarks of Mr. Chatterton :—

"At Bannoor, the people are now beginning to appreciate the advantages of having a rice mill in their midst, and at Sabbenahalli, from the outset they made full use of the cane-crushing plant; but the whole work has so far been done by the departmental agency, and it seems likely that it will be some years before the Co-operative Societies will be able to take over the plants and work them themselves. Our object at the present time is to foster a sense of ownership with its responsibility and to associate and train the local people to manage the undertaking. Ultimate success seems assured, but the goal is a long way off, and it is not easy to devise methods by which departmental control and responsibility may be gradually relinquished."—[EDITOR.]

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The Goat as a Source of Milk.—In the *Journal of the Board of Agriculture,* London, Vol. XXII, No. 7, there is a very practical and useful note on this subject.

In view of the small initial expenditure entailed in the purchase of a goat, minimum housing accommodation required, and the limited amount of cost of food and other maintenance charges and, above

all, the extraordinary hardiness and adaptability of this animal, goats can be profitably kept to supply milk for domestic use and it is for domestic rather than business purposes that the goat is here recommended. There is a widespread belief that goats' milk always possesses a peculiar flavour. This flavour may possibly be caused by the goat feeding on certain herbs, but it is far more probably due to a want of cleanliness of the utensils employed. The rich creamy taste of the goat's milk renders it more attractive to the palate than cow's milk. It is easily digested by children and especially infants. It is also far less likely to contain tubercle bacilli of animal origin.

In selecting a goat the purchaser should look to the following points :—

"The body should be long and fairly deep, although if the latter point is very marked, it is probable that the animal is aged. It is important that the ribs should be well sprung, whilst a long head and a slender neck are generally considered to indicate a good milking strain. If the goat is dry the quality of the udder cannot be ascertained, but if in milk the udder should be carefully examined. It should not only be of good size, but soft and pliable, and the teats should be long and pointed, as they are then most easily handled. It is always desirable for the purchaser to see the goat he is about to buy milked at least once before coming to a decision. This is necessary not merely to ascertain the actual yield, but to find out if the animal stands quietly while being milked. A goat purchased in milk should not be less than two years old or over five. The age can be detected by examining the teeth."

It is stated that in England there are at present five breeds of goats, two of which belong to what may be called the common kind and three to the improved varieties. The common type are English and Irish goats, the superior breeds being the Toggenburg of Swiss origin (the only strictly pure breed in Britain) and the Anglo-Nubian and the crosses "Swiss" and "Anglo-Swiss." The last cross is considered to be probably the best all-round goat in Britain.

Goats breed when very young, often have two, sometimes three, kids at one birth and often produce young twice a year. The period of gestation is about 21 weeks or roughly five months. If a family keeps three goats they may justly look for a regular supply of milk all the year round. Signs of the coming into season are in some cases very transient. They consist in frequent bleating, a constant shaking of the tail, a turgid condition of the vulva, loss of appetite and restlessness and a temporary diminution in the milk-yield if the goat is in milk. This condition will last from one to three days.

If the improvement of the stock for milk production is the object in view, it is essential to secure the services of a male bred from a good milker or still better having "milking blood" on both sides of his parentage. The kids will then be worth rearing. Otherwise it is better to destroy male kids and use all the milk from the goat for domestic purposes. It seldom pays to rear male kids. A well-bred male kid may however be retained if it is not possible to secure near at hand one for service whenever required. The repulsive odour and objectionable habits of he-goats are well known.

In the feeding of goats absolute cleanliness of food and of the receptacle to hold it is required. The use of a metal pail is therefore advocated. Another essential is variety of food as the goat will give up eating if a change is not provided. Economy in feeding should certainly be looked to. From their kid stage goats should be encouraged to eat all vegetable waste from the kitchen or house-hold scraps. Except poisonous shrubs there is hardly any plant which is not acceptable to the goat. Goats are active and industrious feeders.

For the first three or four days after kidding the milk should be fed to the kid as it is not then suitable for human consumption. After that time the goat can be milked twice or thrice daily. Milking should be carried out at regular intervals and the udder completely emptied each time. The more quickly the milking is done the better; otherwise, the goat will become impatient and restless. The last drops or 'strippings' are always the richest. In England an average goat will give at its flush three pints a day:

The total milk-yield in the case of an average goat is about 67 gallons a year, while in the case of better milkers it may go up to 80 to 90 gallons.

In India goats are successfully bred by professional shepherds in districts with moderate or light rainfall and light naturally well-drained soils. A considerable variety of natural herbage in the tract and clean ground to graze each day are essential for raising large flocks of goats and sheep. In small numbers goats are reared in this country and their value as milk-producers appreciated, but there is room for improvement, and goat-keeping for domestic purposes might be extended with great advantage in many districts where it is hardly known.—[EDITOR.]

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IN view of the scantiness of information available as to the relative values of various concentrated foods for dairy cattle in India, the work carried out at Lyallpur, under the direction of Mr. Roberts, Professor of Agriculture in connection with the **feeding of cotton cake** (undecorticated) **to dairy cattle,** and published in the *Journal of Dairying and Dairy Farming in India*, Vol. II, Part III, is of considerable interest. Gram is the usual concentrated food used in the Punjab. Cotton seed is chiefly used in that province for feeding buffaloes and milch animals and also to some extent working animals. For the past few years cotton seed cake has been manufactured in Lahore; its selling price is about Rs. 1-8 per maund f. o. r. Lahore. Eight cows were selected, and divided into two groups of four each. The two groups were nearly alike in total daily milk-yield and in length of lactation period. One group was fed with cotton cake, the other with gram. The cotton cake supplied was always first broken and then moistened for three hours before feeding. Small quantities of the cake were given to start with and this was mixed with gram. The proportion of cake was increased daily and that of gram decreased, until at the end of eight or nine days the gram was entirely replaced. A little trouble was experienced with one cow who refused to eat the cake at first unless mixed with gram. Gradually this was overcome, and later she consumed the cake greedily. At the end of the

second month the total increase in live weight in both the groups was found to be practically equal.

As regards quantity and quality of the milk the advantage after some time was found to be on the side of cotton cake rather than on gram.

It was found that 23 seers of cotton cake had the same nutritive value as 16 seers of gram. The feeding of cotton cake is very economical. Cotton cake costs Rs. 1-11 per maund in Lyallpur while gram runs at about Rs. 3-8 per maund. This will mean considerable saving to a dairyman keeping a herd of say 20 cows.

It appears therefore that cotton cake can be safely and economically fed to dairy cows in milk. It is possible that this food may not be suitable for cows nearing calving time, but further experience on this point is necessary.—[EDITOR.]

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WE print the following extract from a leaflet on "**Some Uses of Prickly-pear**" published by the Department of Agriculture, Madras.

"In parts of Coimbatore district, prickly-pear is used after decomposition and composting as a manure for dry land crops such as *cumbu*, *cholam*, dry *ragi* and garden crops like *ragi*, chillies, tobacco, wheat, plantains, sugar-cane, etc. This is, however, not resorted to by all. In many cases it is prickly-pear growing in corners of their fields or extending from outside into the fields that is cleared and composted by way of disposal. A few ryots compost prickly-pear especially when it is abundantly available near at hand; but this is not followed as much as it might be.

"Ryots, however, have taken up to the practice of carting to their fields the earth which accumulates under prickly-pear bushes for improving their lands. In tank bunds and 'porambokes,' nothing is paid for the earth itself, and the cost is only two annas per cart-load (when the distance to be carted is about half a mile), for clearing the prickly-pear to get at the earth beneath, digging the earth, loading and carting it to the fields. The price per cart is becoming higher gradually owing to the increased wages. The soil under the prickly-pear bushes is of high manurial value as it is very largely composed

of leaf mould and other organic matter blown in by the agency of wind. Prickly-pear itself contains more than 60 per cent. of organic matter (Dr. Leather's analysis) and if such a substance is composted with the rich soil found under these bushes the manurial value will certainly be enhanced. Many of our soils are deficient in organic matter and if a compost of prickly-pear and the soil found under it is made and applied, the result will be beneficial. By composting prickly-pear, ryots not only obtain manure but get rid of this pest which is at present a nuisance in many respects.

"The following methods may be adopted for composting :—

(1) A trench 3′ to 4′ deep and 6′ broad of any required length may be dug and kept ready during the interval between the first and second monsoons. During rainy days when the ryots have not got busy work, prickly-pear may be cut, removed, and filled in the trench and covered with soil that has been removed in digging it. The top of the trench will sink after some days owing to the decay of the stuff and at this stage the soil from under the removed bushes may be dug and thrown on the top. In places having good rainfall, this will make a good compost within one year. If the thorns have not decomposed thoroughly, this may be left for another year when the thorns also will decompose.

(2) In regions of scanty rainfall, prickly-pear may be removed and heaped up in convenient mounds and allowed to dry up during seasons when ryots have enough leisure at their disposal. Dried bushes, grasses, and other rubbish procurable in the vicinity may be spread over the heaps and set fire to. The thorny substance is partially burnt. At this stage the earth removed from under the bushes or from lands close by should be spread all over the heap which can then be left for some years until decomposition is complete. In three or four years, this will be fit for being carted to fields.

(3) If space is not available for the above, circular constructions similar to those used for grinding *chunam* should be made. The prickly-pear is then thrown into this pit and ground by a stone-grinder just as *chunam* is ground. Owing to the large amount of water in the stems the plant, when the stuff is ground, is converted into a jelly-like substance within half an hour and the whole mass

can be removed by *mammuties* and carried to places where compost is to be made. If this is filled in pits or covered with some earth, decomposition will easily set in. The thorns also will not stand erect but will lie flat and the nuisance they cause will be much reduced. In this case the manure will be ready within six to eight months.

" Prickly-pear can also be used to serve other useful purposes than the one above referred to. The water obtained after boiling prickly-pear for some time can be used as a drier in whitewashes. An ordinary pot or *chatti* is filled with prickly-pear cut into small pieces; as much water as the pot will hold is then added. The whole is boiled for about three hours and stirred during the process. When cool, the liquid is strained and added to separately prepared white or colour wash in the proportion of 1 to 150 or 160. Whitewash or colour wash treated in this way becomes fast and does not rub off easily. In Indian houses this fast colour is a great advantage as it does not soil the clothing or body when the newly whitewashed walls are touched."

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THERE has been a revival on the Bombay side of the question of utilizing prickly-pear as fodder for cattle. There is nothing in the discussion that has not been dealt with many times in these columns. In Australia where it has been tried for cattle feeding they seem to be coming to the conclusion that the best thing to be done with this pest is to destroy it utterly, and then if it can be used to any advantage well and good, if not it is a good riddance of bad rubbish. A process has been discovered there of **treating prickly-pear with arsenious trichloride**, by which extensive areas have been completely cleared. In the course of the operations it has been discovered that a big percentage of potash can be obtained from the ash of the prickly-pear, and preparations are being made to enable Australia to supplant Germany in the supply of potash.—(*Madras Mail.*)

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THE Fourth Annual Meeting of the **Indian Science Congress** will be held at Bangalore on the 10th, 11th, 12th, and 13th January

1917. H. H. the Maharaja of Mysore has consented to be Patron of the meeting whilst Sir Alfred Bourne, K.C.I.E., F.R.S., will be the President. The following Sectional Presidents have been appointed :—Mr. J. MacKenna, I.C.S. (Pusa), Agriculture and Applied Chemistry; the Rev. D. Mackichan (Bombay), Physics; Dr. Ziauddin Ahmad, C.I.E. (Aligarh), Mathematics; Mr. K. Ramunni Menon (Madras), Zoology; Mr. C. S. Middlemiss, C.I.E. (Calcutta), Geology; Dr. J. L. Simonsen (Madras), Chemistry.

REVIEWS.

Indian Journal of Economics, Vol. I, Part I, January 1916.—Issued quarterly by the University of Allahabad, Department of Economics. Subscription, Rs. 12 per annum. Single copy, Rs. 4.

We extend a welcome, belated but none-the-less sincere, to the excellent Journal which issues under the editorship of Prof. H. Stanley Jevons. The name is one which will recall many memories of early struggles with formal philosophical conundrums.

In his editorial foreword Prof. Jevons states that the issue of the Journal has been undertaken with a three-fold purpose—(1) to provide a medium for the publication of articles on Indian Economics by authors of standing; (2) to furnish a convenient and compact vehicle of publication for original investigations made by the staff of the Economics Department of the Allahabad University; and (3) to disseminate information about the economic activities of other countries.

The first issue is delightfully Indian in its subjects. It opens with an article on "Agricultural Banks in India" by that enthusiast Mr. D. E. Wacha; and although we must record our emphatic dissent from his opinions we cannot but admit the force and vigour with which Mr. Wacha states his case. Personally we would rather pin our faith to what Mr. Wacha is pleased to call "these new-fangled societies,"—*i.e.*, Co-operative Societies—than to an institution like the Agricultural Bank of Egypt; and we are firmly convinced that not only the financial but also the moral regeneration of India lies in the development of these co-operative societies. Easy money means easy debt. It is quite simple to liquidate a man's debts: it is a slower process to educate him and develop his character so that he will not fall into debt again. But of course

there are two sides to this as to all other questions ; and Mr. Wacha certainly puts his case well.

A short paper on the Indian cotton trade by Prof. Todd is f llowed by a most stimulating paper by our old friend Mr. W. H. Moreland on the Ain-i-Akbari—a possible base line for the economic history of modern India. The figures relate to the latter part of the sixteenth century and the writer considers that if the figures the Ain-i-Akbari contains can be used they will furnish a real starting point for the modern economic history of the country. We hope that this article will act as a stimulus to some of our Indian students of economics to examine critically the available statistics of India before the British Government began to tabulate them. They would command great interest.

The other articles in this issue are an interesting comparison of the Southern States of America with India as regards economic conditions by Prof. Sam Higginbottom ; a paper on Indian factory legislation by Mr. S. H. Fremantle, I.C.S.; and one on the teaching of economics by the editor. A set of able reviews of books on economic and kindred subjects completes the issue.

We congratulate the editor on the form and quality of his first number and we look forward with much interest to future issues. The awakening of an interest in economics, especially the economics of agriculture, is a most healthy sign of progress and we trust that under the stimulus of Prof. Jevons and his staff the circle of Indian workers in this most fascinating subject will be widely extended. —[J. M.]

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Bengal Economic Journal.—Edited by Prof. C. J. HAMILTON and Prof. J. C. COYAJEE. Published by Macmillan & Co., Ltd., Calcutta, Bombay, Madras, and London. Subscription Rs. 10 per annum.

WE have received the first number of the *Bengal Economic Journal* edited by Professors Hamilton and Coyajee, and we take this opportunity of welcoming a Journal which supplies a long felt want.

Economics are all too neglected in India. A little closer study of them in the past would have saved much money, notably in banking circles.

We would especially note the article on "The Moratorium" by Prof. Coyajee, and criticism of the "Report on Co-operation in India" by B. Abdy Collins. There is a cold, calm, hard common sense about them both which is most comforting in these days of lightning finance of the mushroom order. In the article on the Moratorium we would draw special attention to the statement made that "Both France and Germany have been preparing for decades against the present crisis; and yet when the time for action came, the former took refuge under the most comprehensive scheme of moratoria ever devised while the latter adopted a policy of the most lavish extension of loans, and, even then, could not avoid a certain number of moratoria. At least since the Agadir incident the German banks, by Imperial command, have striven to make their resources more liquid and concentrated at home. In France, too, constant preparations have been made both by the Bank of France and by the other great banks for a rapid financial mobilization. A high authority, H. Germain, could say on behalf of the other banks that they were ready for *any* event, if the Bank of France was ready. The present war dissipated all this confidence in a moment." The constant preparations made were of no avail; for the closing of the stock exchange rendered the most liquid securities of all banks unrealizable.

Such a fact should give those connected with finance furiously to think and we hope equally furiously to overhaul their financial machinery and see whether it would be capable of working under such a strain in a land where it is difficult to keep down rumours and to inspire confidence even far away from the actual crisis, and it must not be forgotten that as we increase facility of communication and exchange throughout the world we render the financial failure of one country likely to be felt more and more widely by all others. The days of splendid isolation are gone for ever.

Mr. Collins' remarks on auditors hit a weak spot and their truth is driven home by his reference to Indian banking circles.

In order that co-operative societies may be able to command the confidence of investors it is very necessary that the system of audit and the persons by whom this audit is conducted should be above suspicion. While there is no objection in principle to societies being audited by non-Government auditors licensed by the Registrar—in fact non-official audit is to be preferred as it is less likely to develop into a routine—it must be understood that the audit staff should not depend for their pay and prospects directly upon Central Banks and Unions. It is on these and other grounds that an Audit Federation somewhat on the lines of the Provincial Audit Union of the Central Provinces has much to commend it.

What is wanted in the auditor is local knowledge and sympathy backed by no personal interest in the matter. It has often been said that the manager of the local branch bank in an English agricultural town is the finest agricultural accounts auditor existing. He knows when to be stern and strict and when not to allow undue strictness to interfere with necessary progress because his knowledge enables him to value assets correctly and the valuing of agricultural assets requires a special knowledge which cannot be found in any outsider.

The progress of co-operative societies will render it necessary to train auditors in this line, if they are not to be hindered in their progress, not so much to audit accounts—many can do that—but to put the true value on the assets. His article is of the greatest interest and we hope he will write again. There is still plenty in the report awaiting criticism.—[W. S.]

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A Manual of Elementary Botany for India.—By Rai Bahadur K. RANGA ACHARI, M.A., L.T., Madras. Printed and published by the Superintendent, Government Press, Madras. Price Rs. 2.

UNTIL quite recently the professor or teacher of elementary botany in India was dependent on text-books written in Europe or America. Such books, while excellent in dealing with principles, are ill adapted for use in India, since the plants and conditions described in them are in many cases not found here. There exists a very considerable technical literature regarding Indian botany,

but the digest of that material suitable for a text-book has been made in only a few cases. The work under review is the most recent of these attempts to utilize local material for the elucidation of botanical principles and it certainly is the best work of its kind so far produced. The book has been printed and published by the Government Press, Madras, and the letterpress, plates, and general get-up are excellent. Considering this, the price is amazingly low—a most desirable thing, for Indian students will not, as a rule, indulge in expensive books.

The manual is avowedly elementary, and the writer confines his attention to the flowering plants. The morphology of many local examples is fully explained. The most striking parts of the book are those dealing with the anatomy of plants, illustrated by really convincing original microphotographs. Apart from the value to the student of the morphological and anatomical portions, they are also of value to the teacher in showing him what material to use for the demonstration of special points, and it is hoped that the very excellence of the book on its descriptive side will deter no student or teacher from going direct to the living plant.

As the book does not pretend to be a manual of laboratory practice, detailed directions are not given regarding microscopical technique and the designing of physiological experiments. At the same time it is desirable to develop the physiological section of the book, making it more precise, and dealing at greater length with the evidence on which the necessarily dogmatic text-book statements are based, *e. g.*, in the case of the study of plant nutrition by water cultures (p. 133), and in the case of the statement (p. 185) "it is obvious, that for the production of offsprings, the fusion of the male and female cells is essential even in the case of plants."

In reading through the book the scientific purist may take exception to many minor points, such as the mixing of classification systems by dividing plants into spermaphyta and cryptogams (p. 1), the calling of the web of a girder its flange (p. 91), and the statement that "groups of plants that give a distinctive feature to a locality are called 'formations'" (p. 330); but these detract little from its

value as a text-book. A complete and exhaustive index is however a necessity.

One problem confronting the author of such a book is to produce a work which shall be useful in all parts of this great continent. How far this problem has been solved can only be determined by trial, and we strongly recommend all professors and teachers of elementary botany to make use of the book and communicate their views to the author of the book.

It is to be hoped that in time text-books for India will be produced dealing with more advanced botany and especially with the cryptogams. Is it too much to hope that a group of professors and teachers may collaborate to produce a composite advanced manual for India on the lines of Strasburger's *Text-book of Botany* ?

Manuals of applied botany are also required giving summaries of the great mass of valuable Indian work done in plant breeding, mycology, and economic botany generally.—(W. B.)

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The Year-book of the United States Department of Agriculture, 1915.—(Pages 616, Plates 75. Figs. 13, etc. Washington, Government Printing Office.)

THIS publication is perhaps one of the mirrors in which the economic progress of the world is most comprehensively reflected.

There are two outstanding features in the 1915 issue. One is, of course, the effect of the European war—reflected in the changes in acreage, value, and quantities exported, of crops; the other is the large number of articles which deal with voluntary organization among agriculturists.

With a record yield of wheat in 1914 and an increase of over 25 per cent. in the price, 37 per cent. of the crop grown in the States was exported; and the 1915 crop, estimated at over a thousand million bushels, again beat all records. On the other hand, a cotton crop 14 per cent. greater than that of 1913 was worth one-third less to American farmers, and a decrease of 15 per cent. in the acreage for 1915 coincided with a falling off of 20 per cent. in the yield per acre.

The prospect of a rise in the prices of American exports as compared with those of imports, as a result of the transfer of capital from Europe during the war, should be encouraging to the growers of long-stapled cotton in India.

Seven of the 24 articles in the Year-book relate to co-operative organization of one kind or another, and give a very comprehensive idea of the importance of this movement and the extent to which it can be fostered even in such a home of individualism as the United States.

The movement embraces almost every conceivable aspect of rural economy, from the breeding of livestock and the marketing of crops to dairying and the improvement of roads; and includes such diverse organizations as boys' and girls' clubs for specific purposes, local 'small community' clubs, and mutual insurance companies. In an article on "How the Department of Agriculture promotes Organization in Rural Life," Mr. C. W. Thompson, Specialist in Rural Organization, says:—

"Reviewing all the various types of organization through which the Department of Agriculture seeks to promote the welfare of the farmer, it may be noted that in every case the organization is undertaken for some specific purpose, and that that purpose is one which can better be accomplished through concerted effort than through individual action alone. This represents the general policy of the Department with regard to organization among farmers. The Department does not encourage organization simply for the sake of organization, nor does it encourage the indiscriminate formation of organizations for any and every object whatsoever; for some objects may be accomplished efficiently and economically by individuals working each by himself.

"For the accomplishment of those objects which clearly call for co-operative or co-ordinated action on the part of the farmers, the Department encourages a more efficient use of existing organizations, where that is practicable, either by inducing them to take up new lines of activity, or by pointing out efficient methods of carrying on the activities for which they were originally formed. Where new associations are needed, the Department endeavours to secure

organizations which are as simple in form as possible, and to keep in the foreground the object of the organization rather than the organization itself."

It is difficult to imagine a more effective way of counteracting the centralizing tendencies of Governments whether autocratic or socialistic, than by voluntary organization on these principles; and reading these articles one catches a glimpse of a future when the activities of Governments may be merged in the public recognition and inspection of voluntary associations, not merely organized for agriculture, commerce, or education, but co-ordinated for readily accessible justice, for police, and, on a basis wider and more solid than has ever hitherto been possible, for military defence of the common weal—the ultimate prerogative of centralized authority.—[A.C.D.]

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Note on Cattle of the Bombay Presidency.—Bulletin No. 75 of the Department of Agriculture, Bombay. Printed at the Yeravada Prison Press, Poona. Price As. 3½ or 4*d*.

THIS Bulletin deals with cattle of the Bombay Presidency excluding Sind. The author, Rao Sahib Kelkar, is a senior officer of the Department who is intimately acquainted with the local conditions of his province. The province is divided into nine tracts and in each the conditions are briefly noted on. In the chapters on Breeds of Cattle, Dairy Industry, and Feeding of Cattle, the author has included a large amount of original local information acquired by personal contact with the cattle-owners. Original information of this nature is always valuable, and unless such is put on record agricultural departments stand to lose much valuable material when members leave the service.

A plan is given for the treatment of 50 acres to yield green fodder continuously throughout the year. This problem would, of course, have to be separately worked out for each tract. It will prove a very fruitful source of work and one which will have to be seriously taken in hand in all parts of India.—[G. S. H.]

Dairying and Dairy Breeds (*In Marathi*).—By B. K. Ghare, L. Ag., Pages 11 + 195. Printed by Mahadeo Sakharam Date at the Vaidic Patrika Press. Price Re. 1.

The author of this book, Mr. Bhaskar Kashinath Ghare, L. Ag., Agricultural Lecturer at the Cawnpore Agricultural College, brought out a small pamphlet in Marathi under the title of "Milk and Dairying" three years ago, and the book under review is a much enlarged edition of the same with certain additions and fuller treatment of the subjects dealt with therein. As far as we are aware this is the first book of its kind in Marathi treating so fully and simply about the importance of milk in all its aspects and the care of animals, etc., and is a welcome addition to the literature on technical subjects in that language. The author seems to have made every endeavour to avoid English scientific terms or their high-sounding coined equivalents of Sanskrit origin in his work, and this has tended to make the subject-matter easy of comprehension.

In the introduction written for this book by Mr. M. G. Phatak, L. Ag., the importance of pure milk and its production has been shown in a concise but impressive way, and it conveys to the mind of the reader a vivid idea of dairying and animal husbandry as it should be practised in India.

We find the whole book packed with very useful facts which have been well put together. But we also notice some statements which either require modification or amplification.

The process of secretion of milk as described in Chapter I is too brief to be easily followed and should be made clear enough.

The author, in his enthusiasm for extolling the virtues of milk, has gone the length of attributing to it the power of curing formidable diseases like consumption. We do not doubt the digestibility and nutritive value of pure milk diet in certain diseases, but we cannot agree with him in endowing it with curative powers over this of all the diseases.

In Chapter IV the slope recommended for gutters in the byre for the passage of urine and dung is 6 inches to every 20 feet of

length. This is unnecessarily steep and we believe that a slope of 3 inches to 25 feet of length ought to suffice for this purpose.

In describing circulation of blood the lungs are said to be a part of the circulatory system which is not the case. They belong to the respiratory apparatus.

Chapter VII regarding common ailments of cattle is very meagrely treated. In this chapter under the heading of " Hoven " it is recommended by way of treatment to force the animal to run about. This is a dangerous practice.

In Chapter VIII on cattle-breeding the description of breeds lacks precision, and the illustration used to represent the Jafferabadi buffalo is not a typical one. All the illustrations of cattle are rather indistinct.

There are many typographical mistakes both in figures and words throughout the book, and the author would do well to attend to these and the points referred to above when bringing out another edition of the book.

The book on the whole is very useful and informative and as such it will, we hope, be appreciated by the Marathi-reading public. —[J. H.]

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1st FEBRUARY TO 31st JULY, 1916.

No.	Title	Author	Where published
	GENERAL AGRICULTURE.		
1	The *Agricultural Journal of India*, Vol. XI, Part II. Price Rs. 2; annual subscription Rs. 6.	Issued from the Agricultural Research Institute, Pusa.	Messrs. Thacker, Spink & Co., Calcutta.
2	Special Indian Science Congress number of the *Agricultural Journal of India*. Price Rs. 2 or 3*s*.	Ditto ...	Ditto.
3	Report on the Progress of Agriculture in India for 1914-15. Price As. 5 or 6*d*.	Agricultural Adviser to the Government of India, Pusa.	Government Printing, India, Calcutta.
4	Proceedings of the Board of Agriculture in India, held at Pusa on the 7th February, 1916, and following days (with Appendices). Price Re. 1-2 or 1*s*. 9*d*.	Issued from the Agricultural Research Institute, Pusa.	Ditto.
5	Soil Aeration in Agriculture, Bulletin No. 61 of the Pusa Agricultural Research Institute. Price As. 4 or 5*d*.	A. Howard, C.I.E., M.A., Imperial Economic Botanist.	Ditto.
6	Annual Report of the Board of Scientific Advice for India for the year 1914-15. Price R. 1 or 1*s*. 6*d*.	Issued by the Board of Scientific Advice for India.	Ditto.
7	Agricultural Statistics of India for 1913-14, Vols. I and II. Price Rs. 2-8 and R. 1 respectively.	Issued by the Department of Statistics, India, Calcutta.	Ditto.
8	Estimates of area and yield of principal crops in India for 1914-15. Price As. 4.	Ditto ...	Ditto.
9	Season and Crop Report of Bengal for 1915-16. Price R. 1 or 1*s*. 6*d*.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book Depôt, Calcutta.
10	Groundnut.—Leaflet No. 1 of 1916, of the Bengal Department of Agriculture (for free distribution).	F. Smith, B.Sc., Deputy Director of Agriculture, Bengal.	Obtainable from the Departmen of Agriculture, Bengal.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
11	Agricultural Statistics of Bengal for 1914-15. Price As. 12 or 1*s.* 3*d.*	Issued by the Government of Bengal, Revenue Department.	Bengal Secretariat Book Depôt, Calcutta.
12	Season and Crop Report, Bihar and Orissa for 1915-16. Price As. 6 or 6*d.*	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Bihar and Orissa, Patna.
13	Leaflet on the use of *Dhaincha* ...	Ditto ..	Ditto.
14	*Agricultural Journal* (published half yearly), Vol. III, Part II. Subscription R. 1 per annum.	Ditto ..	Ditto.
15	Agricultural Statistics of Bihar and Orissa for 1914-15.	Ditto ...	Ditto.
16	Report on the Benares Agricultural Station for the year ending 30th June, 1915. Price As. 6 or 6*d.*	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
17	Report on the Government Horticultural Gardens, Lucknow, for the year ending 31st March, 1916. Price As. 4 or 6*d.*	Ditto ...	Ditto.
18	Report on the Government Botanical Gardens, Saharanpur, for the year ending 31st March, 1916. Price As. 4 or 6*d.*	Ditto ...	Ditto.
19	A note on the improvement of the indigenous methods of *Gur* and Sugar making in the United Provinces and a report on the Government Experimental Sugar Factory, Nawabganj, Bareilly District. Price As. 4 or 4*d.*	W. Hulme, Sugar Engineer Expert to the Government of India, and R. P. Sanghi, Sugar Chemist, Experimental Factory, Nawabganj.	Ditto.
20	Year Book of the Punjab Agricultural Department for 1916. Price Re. 1-4.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
21	Prospectus of the Punjab Agricultural College, Lyallpur (for free distribution).	Ditto ...	Ditto.
22	Expenses and Profits of cultivators in the Punjab (for free distribution).	Ditto ..	Ditto.
23	Cotton Survey Report of the Gujranwalla District (for free distribution).		Ditto.
24	Cotton Survey Report of the Jhang District (for free distribution).	Ditto ...	Ditto.
25	Lawrence Gardens' Report. Price Anna 1 or 1*d.*	Ditto ..	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
26	Annual Report of the Department of Agriculture, Bombay, for 1914-15. Price As. 12 or 1*s.* 2*d.*	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
27	Annual Report of the Sukkur Agricultural Station for 1914-15. Price As. 5 6 or 6*d.*	Ditto ...	Ditto.
28	Annual Report of the Surat Agricultural Station for 1914-15. Price Rs. 1-10 or 2*s.* 6*d.*	Ditto ...	Ditto.
29	Annual Report of the Dohad Agricultural Station for 1914-15. Price As. 10-9 or 1*s.*	Ditto ...	Ditto.
30	Annual Report of the Dhulia Agricultural Station for 1914-15. Price As. 10-6 or 1*s.*	Ditto ...	Ditto.
31	Annual Report of the Jalgaon Agricultural Station for 1914-15. Price As. 9-9 or 11*d.*	Ditto ...	Ditto.
32	Annual Report of the Nadiad Agricultural Station for 1914-15. Price As. 13 or 1*s.* 3*d.*	Ditto ...	Ditto.
33	Annual Report of the Gokak Canal Agricultural Station for 1914-15. Price As. 11-3 or 1*s.* 1*d.*	Ditto ...	Ditto.
34	Annual Report of the Gadag Agricultural Station for 1914-15. Price As. 9-9 or 11*d.*	Ditto ...	Ditto
35	Annual Report of the Dharwar Agricultural Station for 1914-15. Price As. 13-9 or 1*s.* 4*d.*	Ditto ...	Ditto.
36	Annual Report of the Alibag Agricultural Station for 1914-15. Price As. 10-6 or 1*s.*	Ditto ..	Ditto.
37	Annual Report of the Ratnagiri Agricultural Station for 1914-15. Price As. 9-6 or 11*d.*	Ditto ...	Ditto.
38	Annual Report of the Mirpurkhas Agricultural Station for 1914-15. Price As. 5-3 or 6*d.*	Ditto ...	Ditto.
39	Annual Report of the Landhi Agricultural Station for 1914-15. Price As. 4-6 or 5*d.*	Ditto ...	Ditto.
40	Annual Report of the Larkhana Agricultural Station for 1914-15. Price As. 4-6 or 5*d.*	Ditto ...	Ditto.
41	Annual Report of the Manjri Agricultural Station for 1914-15. Price As. 14 or 1*s.* 4*d.*	Ditto ...	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
42	Annual Report of the Experimental plots in Satara and Sholapur Districts for 1914-15. Price As. 1-6 or 2*d.*	Issued by the Department of Agriculture, Bombay.	Government Central P Bombay.
43	Annual Report of the Ganeshkhind Botanical Gardens for 1914-15. Price As. 4 or 5*d.*	Ditto ...	Ditto.
44	Annual Report of the Agricultural College Dairy, Kirkee, for 1914-15. Price As. 4 or 5*d.*	Ditto ..	Ditto.
45	Annual Report of the Poona Agricultural College Farm for 1914-15. Price Re. 1-1 or 1*s.* 7*d.*	Ditto ...	Ditto.
46	Annual Report on the Experimental work of the Economic Botanist and his staff for 1914-15. Price As. 2 or 3*d.*	Ditto ..	Ditto.
47	Report on the Committee appointed to consider measures for the improvement of the milk supply in large cities in the Bombay Presidency. Price As. 3 or 3*d.*	G. F. Keatinge, C.I.E., I.C.S., President of the Committee.	Ditto.
48	Note on Cattle of the Bombay Presidency. Bulletin No. 75 of 1915 of the Department of Agriculture, Bombay. Price As. 3-6 or 4*d.*	Rao Sahib G. K. Kolkar.	Ditto.
49	Artificial Manures—Experiments with their value for crops in Western India. Bulletin No. 76 of 1915 of the Department of Agriculture, Bombay. Price As. 4 or 5*d.*	Harold H. Mann, D.Sc., and S. R. Paranjpe, B.Sc.	Ditto.
50	Experience of Kalli Chitti Abhoye Naidu of Pulla, Kistna District, on Green Manure. Leaflet No. 1 of 1916 of the Department of Agriculture, Madras.	Chitti Abhoye Naidu ...	Government Press, Madras.
51	Some Uses of Prickly Pear. Leaflet No. 2 of 1916 of the Department of Agriculture, Madras.	J. Chelva Ranga Raju ...	Ditto.
52	Groundnut cultivation in the Upland Taluks of the Godavari District. Leaflet No. 3 of 1916 of the Department of Agriculture, Madras.	D. Balakrishna Murthi ..	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
53	Pulichai, Mailam, or Jari Cotton in Tinnevelly and Ramnad Districts. Leaflet No. 4 of 1916 of the Madras Department of Agriculture.	G. A. D. Stuart, I.C.S. ...	Government Press, Madras.
54	The *Agricultural and Co-operative Gazette* (Monthly) from February to July, 1916. Price As. 2 per issue.	Issued by the Department of Agriculture, Central Provinces and Berar.	Shalom Press, Nagpur.
55	A Handbook of Agricultural Leaflets (in Hindi). Price As. 3-6.	G. Evans, M.A., Deputy Director of Agriculture, Northern Circle, Jubbulpur.	George Printing Press, Jubbulpur.
56	Season and Crop Report of Burma for the year ending 30th June, 1916. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
57	Report of the Mandalay Agricultural Station (including Natywagon Sub-Station) for the year 1914-15. Price As. 6 or 7*d*.	Ditto ...	Ditto.
58	Report of the Padu Agricultural Station for the year 1914-15. Price As. 2 or 2*d*.	Ditto ...	Ditto.
59	Report of the Buggi Experimental Plot for the year 1914-15. Price As. 2 or 2*d*.	Ditto ...	Ditto.
60	Burma Agricultural Calendar for 1916-17 (in Burmese).	Ditto ...	Ditto.
61	Minutes of the 8th Half Yearly Conference of the Agricultural Department held at Maymyo on the 17th and 18th April, 1916.	Ditto ...	Ditto.
62	Sugarcane Cultivation—Cultivators' Leaflet No. 46 of the Department of Agriculture, Burma.	A. Mackerral, M.A., B.SC., Deputy Director of Agriculture, Southern Circle, Burma.	Ditto.
63	Report on the Season and Crops of Assam for 1915-16. Price As. 8 or 9*d*.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
64	Summary of Remarks on the Kharif Crops of the North-West Frontier Province for 1915. Price As. 4 or 4*d*.	Issued by the Department of Agriculture, North-West Frontier Province.	... ..
65	The *Journal of the Madras Agricultural Students' Union* (Monthly). Annual Subscription, R. 1.	Madras Agricultural Students' Union.	Literary Sun Press, Coimbatore.
66	*Quarterly Journal of the Indian Tea Association.* Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—concld.		
67	The *Journal of Dairying and Dairy Farming in India.* (Issued quarterly).	Published by the Indian Committee of the Dairy Education Association.	Messrs. Thacker, Spink & Co., Calcutta.
68	*Poona Agricultural College Magazine* (Quarterly). Annual Subscription, Rs. 2.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.
69	Report on the Working of the Government Gardens and Parks in Mysore for 1914-15.	Issued by the Department of Agriculture, Mysore.	Government Press, Bangalore.
70	Report on the Operations of the Department of Agriculture and Fisheries, Travancore for 1914-15.	Issued by the Department of Agriculture, Travancore.	Government Press, Trivandrum.
	AGRICULTURAL CHEMISTRY.		
71	The Gases of Swamp Rice Soils, Part III. A Hydrogen-oxidizing Bacterium from these Soils. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IV, No. 4. Price As. 12 or 1*s*.	W. H. Harrison, M.SC., Government Agricultural Chemist, Madras, and P. A. Subramania Aiyer, B.A., Assistant to the Government Agricultural Chemist.	Messrs. Thacker, Spink & Co., Calcutta.
72	Some Factors affecting the cooking of Dholl (*Cajanus indicus*). Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IV, No. 5. Price R. 1 or 1*s*. 6*d*.	B. Viswanath, T. Lakshman Row, B.A., and P. A. Raghunathaswami Ayyangar, D.A., Assistants to the Government Agricultural Chemist, Madras.	Ditto.
73	Studies in the Chemistry and Physiology of the leaves of the Betel vine (*Piper betle*) and of the Commercial bleaching of betel-vine leaves. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IV, No. 7. Price R. 1 or 1*s*. 6*d*.	Harold H. Mann, D.SC., Agricultural Chemist to the Government of Bombay, and V. G. Patwardhan, B.Ag.	Ditto.
74	Note on the Soil of the Experimental Farms. Bulletin No. 13 of 1916 of the Department of Agriculture, Burma. Price As. 2 or 2*d*.	F. J. Warth, M.SC., Agricultural Chemist, Burma.	Government Printing, Burma, Rangoon.
75	A Soil Survey of the Guntur Delta. Bulletin No. 70 of the Department of Agriculture, Madras. Price Re. 1-8 or 2*s* 3*d*.	W. H. Harrison, M.SC., and B. Vishwanath.	Government Press, Madras.
	BOTANY.		
76	Some Varieties of Indian Gram (*Cicer arietinum*, L.). Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VII, No. 6. Price R. 1 or 1*s*. 6*d*.	Albert Howard, C.I.E., M.A.; Gabrielle L. C. Howard, M.A.; and Abdur Rahman Khan, Second Assistant to the Imperial Economic Botanist.	Messrs. Thacker, Spink & Co., Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	Botany—contd.		
77	Studies in Indian Oil-seeds, No. 1, Safflower and Mustard. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VII, No. 7. Price Re. 1-8 or 2*s*. 6*d*.	Albert Howard, C.I.E., M.A.; Gabrielle L. C. Howard, M.A.; and Abdur Rahman Khan, Second Assistant to the Imperial Economic Botanist.	Messrs. Thacker, Spink & Co., Calcutta.
78	Studies in Indian Sugarcanes, No. 2. Sugarcane Seedlings, including some correlations between Morphological Characters and Sucrose in the Juice. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. VIII, No. 3. Price Rs. 3 or 4*s*. 3*d*.	C. A. Barber, SC.D. (Cantab.), Government Sugarcane Expert, Madras.	Ditto.
79	An Account of the Genus *Capsicum* grown in the Central Provinces and Berar. Bulletin No. 5 of the Central Provinces Department of Agriculture (only 50 copies available for sale).	K. P. Shrivastava, Assistant Economic Botanist, Central Provinces.	Government Press, Central Provinces, Nagpur.
	MYCOLOGY.		
80	Black Thread Disease of *Hevea* in Burma. Bulletin No. 14 of 1916 of the Department of Agriculture, Burma. Price As. 2 or 2*d*.	J. F. Dastur, B.SC., 1st Assistant to the Imperial Mycologist, Pusa.	Government Printing, Burma, Rangoon.
	ENTOMOLOGY.		
81	One Hundred Notes on Indian Insects. Bulletin No. 59 of the Agricultural Research Institute, Pusa. Price As. 8 or 9*d*.	T. Bainbrigge Fletcher, F.L.S., F.E.S., F.Z.S., Imperial Entomologist.	Government Printing India, Calcutta.
82	First Report on the Experiments carried out at Pusa to improve the Mulberry Silk Industry, compiled under the direction of the Imperial Entomologist. Bulletin No. 48 of the Agricultural Research Institute, Pusa. Price As. 6 or 7*d*. (Translated into Bengali.)	M. N. De, Sericultural Assistant, Pusa.	India Press, Calcutta.
83	The Mango Shoot-borer. Leaflet No. 2 of 1916 of the Bengal Department of Agriculture (for free distribution).	P. C. Sen, Entomological Collector, Bengal.	Obtainable from the Department of Agriculture, Bengal.
	VETERINARY.		
84	Statistics compiled by the Government of India from the Reports of Provincial Civil Veterinary Departments for 1914-15.	Issued by the Government of India, Revenue and Agriculture Department.	Government Printing, India, Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*concld.*

No.	Title	Author	Where published
		Veterinary—contd.	
85	Some Diseases of Cattle in India, 1916. A handbook for stock owners (revised, 4th edition.) Price As. 8 or 9*d.*	Major G. K. Walker, C.I.E., Superintendent, Civil Veterinary Department, Bombay.	Government Printing, India, Calcutta.
86	Annual Report of the Civil Veterinary Department, Bihar and Orissa for 1915-16.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Bihar and Orissa, Patna.
87	Annual Report of the Civil Veterinary Department, United Provinces, for the year ending 31st March, 1916.	Issued by the Department of Agriculture, United Provinces.	Government Press, Allahabad.
88	Annual Administration Report of the Civil Veterinary Department, Madras Presidency, for 1914-15. Price Re. 1-2 or 1*s.* 9*d.*	Issued by the Civil Veterinary Department, Madras.	Government Press, Madras.
89	Report on the Working of the Civil Veterinary Department, Central Provinces and Berar, for 1915-16. Price R. 1 or 1*s.* 6*d.*	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.
90	Annual Report of the Government Stud Farm at Kunigal, Mysore, for 1914-15.	Issued by the Department of Agriculture, Mysore.	Government Press, Bangalore.

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(9) RAI SAHIB M. GULAB SINGH & SONS, LAHORE.
(10) MANAGER, EDUCATIONAL BOOK DEPOT, NAGPUR.

Annual Report of the Imperial Department of Agriculture in India for the year 1904-05. Price, As. 12 or 1*s*. 2*d*. (*Out of print.*)
Report of the Imperial Department of Agriculture in India for the years 1905-06 and 1906-07. Price, As. 6 or 7*d*.
Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for the years 1907-09. Price, As. 4 or 5*d*.
Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for the year 1909-10. Price, As. 4 or 5*d*.
Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for the year 1910-11. Price, As. 6 or 7*d*.
Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for the year 1911-12. Price, As. 6 or 7*d*.
Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for the year 1912-13. Price, As. 7 or 8*d*.
Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for the year 1913-14. Price, As. 8 or 9*d*.
Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist) for the year 1914-15. Price, As. 8 or 9*d*.
Report on the Progress of Agriculture in India for the years 1907-09. Price, As. 6 or 7*d*.
Report on the Progress of Agriculture in India for the year 1909-10. Price, As. 6 or 7*d*.
Report on the Progress of Agriculture in India for the year 1910-11. Price, As. 12 or 1*s*. 3*d*. (*Out of print.*)
Report on the Progress of Agriculture in India for the year 1911-12. Price, As. 6 or 7*d*.
Report on the Progress of Agriculture in India for the year 1912-13. Price, As. 8 or 9*d*.
Report on the Progress of Agriculture in India for the year 1913-14. Price, As. 8 or 9*d*.
Report on the Progress of Agriculture in India for the year 1914-15. Price, As. 5 or 6*d*.
Proceedings of the Inter-Provincial Jute Conference held at Calcutta from the 2nd to 4th August 1915 (with Appendices). Price, As. 6 or 7*d*.
Proceedings of the Board of Agriculture in India, held at Pusa on the 6th January 1905 and following days (with Appendices). Price, As. 8 or 9*d*.
Proceedings of the Board of Agriculture in India, held at Pusa on the 15th January 1906 and following days (with Appendices). Price, As. 12 or 1*s*. 2*d*.
Proceedings of the Board of Agriculture in India, held at Cawnpur on the 18th February 1907 and following days (with Appendices). Price, Re. 1-2 or 1*s*. 6*d*.
Proceedings of the Board of Agriculture in India, held at Pusa on the 17th February 1908 and following days (with Appendices). Price, As. 8 or 9*d*.
Proceedings of the Board of Agriculture in India, held at Nagpur on the 15th February 1909 and following days (with Appendices). Price, As. 8 or 9*d*.
Proceedings of the Board of Agriculture in India, held at Pusa on the 21st February 1910 and following days (with Appendices). Price, As. 8 or 9*d*.
Proceedings of the Board of Agriculture in India, held at Pusa on the 20th November 1911 and following days (with Appendices). Price, As. 10 or 1*s*. (*Out of print.*)
Proceedings of the Board of Agriculture in India, held at Coimbatore on the 8th December 1913 and following days (with Appendices). Price, Re. 1-2 or 1*s*. 9*d*.
Proceedings of the Board of Agriculture in India held at Pusa on the 7th February 1916 and following days (with Appendices). Price, Re. 1-2 or 1*s*. 9*d*.
Standard Curriculum for Provincial Agricultural Colleges as recommended by the Board of Agriculture, 1908. Price, As. 4 or 5*d*.
The *Agricultural Journal of India*. A Quarterly Journal dealing with subjects connected with agricultural economics, field and garden crops, economic plants and fruits, soils, manures, methods of cultivation, irrigation, climatic conditions, insect pests, fungus diseases, co-operative credit, agricultural cattle, farm implements and other agricultural matters in India. Illustrations, including coloured plates, form a prominent feature of the Journal. It is edited by the Agricultural Adviser to the Government of India, with the assistance of the Staff of the Pusa Agricultural Research Institute, *Annual Subscription*, Rs. 6 or 8*s*. 6*d*. including postage. Single copy, Rs. 2 or 3*s*.

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA are issued from time to time as matter is available, in separate series, such as Chemistry, Botany, Entomology, and the like.

BOTANICAL SERIES.

Vol. I, No. I. Studies in Root-Parasitism. The Haustorium of *Santalum album.*—Part I.—Early Stages, up to Penetration, by C. A. BARBER, M.A., F.L.S. Price, R. 1. *(Out of print.)*
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PREFACE.

THE Third Indian Science Congress held at Lucknow in February 1916, was a great improvement on the first and second meetings, and the expectations of the promoters as to the advantages of such meetings were on this occasion shown to be justified. The Indian departmental system of Government is apt to restrict correspondence between members of its numerous scientific departments and public and private institutions and to create a state of water-tight compartments. This is a serious drawback to the interests of scientific progress in a country where most of the scientific work is carried on under the auspices of Government. A Science Congress breaks down these barriers and brings together men of varied shades of opinion in every branch of scientific activity, and enables them to check and discuss problems in a manner for which the ordinary Government reports and publications offer no corresponding facilities. It also aids in the sifting of the good from the bad and gives the public, which is none too well informed on scientific matters, an opportunity of becoming acquainted with the doings of science. For these reasons the Indian Science Congress would seem to deserve every encouragement. It is hoped that it will continue to improve and become a powerful weapon for the aid and advancement of scientific progress in India.

One of the features of the last Congress was the creation of an Agricultural Section in which papers related to problems affecting the agricultural industry were read and discussed. Some of these are of considerable interest, and it is thought that to bring out a selection in the form of a Special Congress Number of the Agricultural Journal of India will be appreciated by the readers of the Journal. This explains the reasons for the present issue.

INDORE :
Dated the 5th May, 1916.

BERNARD COVENTRY.

With acknowledgments to the Asiatic Society of Bengal, under whose auspices the Indian Science Congress was held, for their kindness in allowing us to publish the papers contained in this number *in extenso*.

EDUCATION IN ITS RELATION TO AGRICULTURE.

BY

BERNARD COVENTRY, C.I.E.,

Late Agricultural Adviser to the Government of India and Director of the Pusa Agricultural Research Institute.

"I am no educator, no teacher; I have made no psychological study of young people from an educational point of view, nor of the different methods of teaching suited to different ages, no statistical investigation of the influence of particular curricula in training the mind or furnishing it with useful information. I have, in short, neither made contributions to the science of education nor practised the art ....I can speak only as a member of the general public—not as an expert................not that I regard the view of the general public as unimportant................ The general public must, as all will admit, decide what is to be spent on education or, more strictly, on schools and colleges and professional educators, out of both public and private income— it is for them to decide on its relation to other social and family needs. But the concern of the public with education is not merely financial and administrative. It is more intimate than that. For education is not a subject like physics or chemistry on which only an expert has a right to an independent view. There are, no doubt, aspects of it of which only the expert can properly judge, there are experiments in it which only the expert can advantageously try, and there are, of course, departments of it in which the opinion of the expert is indispensable. But without depreciating either the science and art of education, it is clear that when we take education in its widest sense it concerns everybody and almost everybody is bound to have views about it."

These words were spoken by no less a person than Mrs. Henry Sidgwick in her address as President of the Section on Educational Science at the recent meeting of the British Association at Manchester.

I feel like Mrs. Sidgwick that I am "no educator and no teacher" and that an apology or at least an explanation is required from me for troubling you to-day in a subject on which I am not an expert. But when we have it on such an authority as Mrs. Sidgwick that education "concerns everybody and almost everybody is bound to have views about it" I feel I have a measure of sanction for imposing my views upon you. I do not propose, however, to make full use of this sanction and tell you all I think about education, but I propose to restrict my remarks to education in its relation to agriculture and further with the exception of an introductory statement dealing with a few facts, I do not propose to say much on the education of youth, but of that of the adult. You will probably all admit that this is quite a novel and peculiar way of dealing with the question of education, but I trust you will find it none the less interesting and instructive. I should like to say before I go any further that I claim no credit for the ideas I shall place before you. They all come from America and, like everything that comes from that wonderful country, they are exceedingly "cute" and practical and in my opinion are eminently applicable to India.

The population of British India comprises over 255 million souls. Of this vast multitude 80 per cent. or over 200 millions, that is to say, 4 in every 5 are dependent on agriculture. Any educational system therefore which does not take into consideration the relationship it should bear to agriculture is likely to be at a disadvantage. It is on the importance of this aspect of the educational problem I intend to address my remarks. Now out of the whole population, 7½ millions or about 3 per cent. are scholars, though 15 per cent. or 36 millions are of the school-going age. Thus only 20 per cent. of those of the school-going age receive any education at all. Of these 7½ million scholars, about 1 million proceed to secondary education and about 40,000 reach a University career.

In judging of these figures in relation to the agricultural industry it should be borne in mind that the percentage of scholars is much higher in the urban than in the rural areas and also that a very large number of rural scholars never get more than a mere smattering of the most elementary education; so that educational efficiency in rural areas is very much lower than the official returns of general education would indicate. I may appropriately refer here to a small brochure entitled "A Policy of Rural Education" by Mr. S. H. Fremantle[1], the Collector of Allahabad, which has quite recently been published and which is well worthy of perusal. He complains how both in urban and rural schools education is too literary and how primary schools are worked for the benefit of that small section which can afford a secondary education and not in the interests of the overwhelming majority of agriculturists, most of whom abandon their studies after a few months. I think Mr. Fremantle is right. It means that very few indeed of the agricultural population get any education at all, and that, as a class, it can be put down as almost illiterate. The authorities have not been ignorant of these facts, and it is not from want of trying to improve matters that things are at such a low ebb. Much has been done in recent years to improve our system of education, especially in its relation to agriculture and the subject may be said to have received an unwonted measure of attention. In 1901 an important Conference was held at Simla presided over by Lord Curzon which led to a complete overhauling of the existing educational machinery. A policy of reform was then started, the vitalizing influence of which is felt to this day. A department of education was created with a member of council in charge. Money grants were increased and they have still further increased, as a result of keen interest taken by the present Viceroy, Lord Hardinge, who has made education a special object of his attention. Thus the total expenditure which in 1901 was 4 crores, to-day is over 10 crores. The number of pupils in 1901 was 3⅞ millions, to-day it is 7½ millions. Interest has been stimulated in every quarter and expansion is noticeable in every branch.

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[1] Fremantle, S. H., *A Policy of Rural Education*. W. Newman & Co., Calcutta.

Agricultural and rural education have had quite a fair share of attention, and the need which exists for connecting the teaching of the schools with our chief industry has been and still is fully recognized. I therefore do not complain of want of endeavour. But it cannot be said that these efforts have been crowned with the success one would have wished. But if we have to admit failure, whether complete or partial, we have gained considerably by the discussions which have resulted and by the light which has been thrown on the difficulties inherent in the problem.

The occasion when agricultural education rst seriously engaged the attention of Government and the people was in 1904, when the policy for improving the agricultural industry was started by Lord Curzon. At first it was the intention to restrict efforts to improving the industry itself, but later, influenced no doubt by the examples of advanced schemes abroad, the Government elaborated a policy under which not only research and experiment, but agricultural education proper, formed an important and integral part. Large sums of money were devoted to the erection of agricultural colleges in nearly all the Provinces. Syllabuses were prepared by the Board of Agriculture and the Colleges were empowered to grant a diploma of Licentiate of Agriculture. At first, signs of success were not wanting. Candidates freely offered themselves for admission and there was found no difficulty in filling the colleges. However, as time rolled on, a decline in admissions became perceptible until the year 1913 when, in some colleges, the position became acute and the matter was brought up for consideration before the Board of Agriculture. The proceedings of the Board in that year indicate the general failure of the schemes drawn up in 1906 and 1908, and we find it expressed that the courses were found not to be suited to the class of students for which the colleges were intended, that the demand and utility for the course is obscured by its being made a road to a degree, that college graduates engaged on the subordinate staff of the Agricultural Department, with very few exceptions, failed to show any power to develop any original line, that intelligent inquisitiveness and power of independent thought was lacking,

that the course engendered too much cram and too little power of application, and so forth. What was the root-cause of this failure would appear to be explained in one of the resolutions which stated "that the general standard embodied in the Matriculation or University Entrance Examination does not provide a sufficient basis to enable a student to take full advantage of the higher instruction obtainable in the existing agricultural colleges in India "[1] and the Board recommended that a general higher education is necessary in all students admitted to such a course. In other words, it would appear that the standard of general education in the country was too low to afford suitable material with which to man colleges of such an advanced type as those which had been set up by the Agricultural Department. In fact, the colleges as educational centres were ahead of the times—primary and secondary education was too backward. Consequently the Board suggested a compromise by lowering the standard of the college curriculum to meet existing conditions and expressed its approval of a two years' preliminary practical course, which had been prepared for the agricultural college at Coimbatore as an introduction to the more advanced course. Many of the colleges have since adopted this, with the result that admissions have considerably increased. While we may expect that the Department will benefit by an increase of recruits for filling its subordinate posts, it has yet to be seen how far the education of the cultivators will be influenced by the change. My own view is that these colleges as instruments for education will not accomplish very much, for the simple reason that they are ahead of the times and that there can be no real demand on the part of the youth of the country for an advanced agricultural course until considerable progress has been made in primary and secondary education and in the improvement of agricultural methods. Not until the industry is more highly developed and the standard of living has been raised, will there arise a demand for higher education amongst the agricultural classes.

[1] *Proceedings of the Board of Agriculture in India*, 1913, p. 42. Government Printing, India, Calcutta.

The creation of agricultural colleges, however, is by no means the only effort that has been made to improve the education of our agricultural youth. Agricultural schools under the supervision of the Agricultural Department have been started in some provinces which were commended by the Board. They give considerable promise of success and, in my belief, deserve every encouragement. Also, there have been attempts in all provinces to set up a system of rural education by imparting instruction based upon the agricultural surroundings of the children, and endeavours have been made to use nature study as a means to that end. But so far the results, we must admit, have been of a microscopic character.

But there is a form of education which is not included in those I have mentioned and is unknown in India. It is a form of education which has been adopted in certain parts of America and which has of late attracted a considerable amount of attention. It is, in my humble opinion, applicable to the conditions existing in India, and offers opportunities in which officers of the Agricultural and Educational Departments could profitably combine to make the problem of education of the masses easier and more efficient. I will give a brief description.

In America general education is carried on chiefly by the Government by whom large sums of money are yearly allotted to the cause of education, but privately supported colleges are abundant and both these and Government schools are largely assisted by private benefactions, the most important of which are controlled by a private body known as the General Education Board.

Ten years ago great interest had arisen in the upraising of the Southern States whose industrial and educational conditions had fallen very much behind those of the Northern States. Conditions in the Southern States resemble in many particulars those which obtain in rural India. About 80 per cent. of the population is agricultural, depending for its livelihood almost entirely on the produce of the soil. There was great backwardness in both educational and industrial progress. Unfavourable economic conditions existed which were mainly the result of rural poverty. While the average

annual earnings of agriculturists in the Northern States were more than 1,000 dollars, those in the Southern States were as low as 150 dollars. Under the auspices of the General Education Board an enquiry was set on foot to study the educational conditions in the Southern States and to devise the ways and means for improving them. The very practical way in which the enquiry was conducted is characteristic of the American people. Surveys were planned State by State, conferences were held, monographs were prepared, dealing with the various points on the organization of education. The conclusions which resulted from this enquiry are peculiar. To quote from the Report, it "convinced the Board that no fund, however large, could, by direct gifts, contribute a system of public schools; that even if it were possible to develop a system of public schools by private gifts, it would be a positive disservice. .... The public school must represent community ideals, community initiative, and community support, even to the point of sacrifice."[1] The Board therefore resolved that assistance should be given not by foisting upon the Southern States a programme of education from outside, but by aiding them and co-operating with them in educating themselves. When, however, it proceeded to apply these principles it was faced with the following initial difficulties. They found the people had not enough money, "that adequate development could not take place until the available resources of the people were greatly enlarged. School systems could not be given to them, and they were not prosperous enough to support them." "Salaries were too low to support a teaching profession................Competent professional training could not exist; satisfactory equipment could not be provided."[2] These conditions were primarily the result of rural poverty. The great bulk of the people was not earning enough to provide good schools and the prime need was money. The Board therefore came to the conclusion that it could render no substantial educational service until the farmers could provide themselves with larger incomes,

[1] *General Education Board. An Account of its Activities,* 1902—1914. 61 Broadway, New York.

[2] *Ibid.*

and consequently they resolved that it was necessary first to improve the agriculture of the Southern States. Now mark what followed. The Board was first advised to address itself to the rising generation and to support the teaching of agriculture in the common schools. But after thoughtful consideration this plan was rejected. They found that in the absence of trained teachers, the effort was impracticable; moreover, there were no funds with which to pay such teachers, and the instruction itself would not materially contribute to its own support. Finally, it was impossible to force intelligent agricultural instruction upon schools whose patrons were not themselves alive to the deficiencies of their own agricultural methods. Until the public was convinced of the feasibility of superior and more productive methods the public schools could not be reconstructed; once the public was convinced and, by reason thereof, better able to stand the increased cost, the schools would naturally and inevitably re-adjust themselves.

"It was therefore deliberately decided to undertake the agricultural education not of the future farmer, but of the present farmer, on the theory that, if he could be substantially helped, he would gladly support better schools in more and more liberal fashion."[1] The Board, therefore, set about an extensive enquiry as to the best means of conveying to the average working farmer of the South, in his manhood, the most efficient known methods of intelligent farming. As a result of this enquiry a movement known as the Co-operative Farm Demonstration was set up. A year was spent in discovering the most effective methods of teaching improved agricultural methods to adult farmers. Dr. Seaman Knapp of the United States Department of Agriculture was engaged to show farmers how to improve their agricultural methods and raise the standard of their industry. It was not long before successful results were obtained. Under improved treatment it may be roughly stated that the crop yields were doubled. Thus in 1909 the average yield in pounds of seed cotton was 503·6 per acre: on demonstration farms the average was 906·1 pounds; in 1910

[1] *General Education Board. An Account of its Activities,* 1902—1914.

the figures were 512·1 and 858·9 respectively; in 1911, 624·6 and 1081·8; and in 1912, 579·6 and 1054·8.

In the growing of corn similar results were obtained. In 1909 the ordinary average yield was 16·7 bushels per acre, while on the demonstration farms it was 31·7 bushels per acre. In 1910, 19·3 and 35·3, in 1911, 15·8 and 33·2, and in 1912, 19·6 and 35·4. It is further stated that the poorer the season, the more clearly did the demonstration methods prove their superiority. The work was also studied from the standpoint of the farmer's financial profit. "In Alabama, for example, in 1912, the average yield of lint cotton was 173 pounds per acre; but demonstration acres averaged 428·3 pounds. Demonstration methods, therefore, netted the farmer 255·3 pounds per acre. At the average price of 65 dollars a bale for lint and seed, the farmer made an extra 33 dollars per acre; as there were 8,221 acres under cultivation on the demonstration methods, the total gain was 271,000 dollars. In the same year 7,402 acres were under cultivation in demonstration corn. Demonstration acres averaged 26·9 bushels more per acre than the general average for the State. The demonstration farmers of the State pocketed 139,379·66 in consequence."[1] This was of course in one State alone. These methods have not been restricted to cotton and corn, but have been applied to a very large number of crops and the propaganda is not limited to cultural methods, but is applied equally to the improvement in farm equipment, more comfortable houses, better barns, stronger teams, better implements, and cleaner and healthier surroundings. Hence it is claimed that the beneficent results of this work are not limited to financial profit and cannot entirely be measured by money. Characteristic examples of the relief which the new system brought are cited, but one example will suffice. In Mississippi 5 years ago the value of a certain farmer's produce was one dollar per acre and he was 800 dollars in debt. In 1909 his entire farm was worked under the Government method. He averaged 1,100 lb. of cotton against his neighbour's 300 to 400 lb. He made besides 500 bushels of corn and from one

[1] *Ibid.*

special demonstration acre realized 152 barrels of high class seed which he sold for 300 dollars. His debts are now paid and he has cash in the bank. So much for the education of the adult farmer. We now come to the effect this movement has had on the education of youth. We are told that the initiation of demonstration work and the application of the principle of co-operation has resulted in the disappearance of the disorganization characteristic of rural life. Colleges of agriculture, farmers' institutes, agricultural high schools, "Boys' Corn Clubs," "Girls' Canning and Poultry Clubs," and the like have been brought into existence where practically none of these things existed before, and that the social and educational awakening of the rural South is recognized as being a bye-product of the demonstration movement. Statistics show that the provision for schools has steadily increased. Thus the expenditure for public, elementary, and secondary schools in North Carolina which was 1,091,226 dollars in 1901, is 4,300,000 in 1913. In South Carolina the expenditure which was 961,897 dollars in 1901 is 2,609,766 in 1913, Arkansas 1,369,809 and 4,279,478, and so forth. These instances give but meagre examples of the important results achieved by the demonstration movement. For greater detail I must refer you to the Report[1] itself.

I think you will agree with me that the educational policy I have described is novel and peculiar. When I say novel, I do not mean that demonstration work has not been used before among farmers and cultivators. We all know that it has, but it is novel in the sense, that never before, so far as I am aware, has demonstration been used in any country as a force and weapon for education so as to make it a condition precedent to the education of youth. It is a new experiment but a new experiment of a remarkable kind. The results indicate that it is no use to try and educate youth if you do not first secure the welfare of the community to which it belongs and that therefore the development of resources should precede education in order of time. What the American General Board of Education says to the farmer in the Southern States is—You

[1] *Ibid.*

are too poor to supply your sons with education; we could assist you, but we do not consider it proper to do so, unless you yourselves contribute. As you cannot do this, we will assist you to increase your earnings so that you will be in a position to provide yourself with schools. When you have done this we will assist you further. We consider that it would be wrong for us to directly educate the rising generation, if you are not able to participate; in fact, we believe that it would be a positive disservice for us to do so. Your schools should be started by yourselves, they should represent community ideals, community initiative, and community support even to the point of sacrifice.

We have seen how the experiment has succeeded. Might we not with advantage apply the same principles to India? Might we not invite the co-operation of the Agricultural Department in a general scheme and policy of education? Is there any likelihood of success without this? Can we hope to give the youth of this country an adequate educational service unless we go to the root of things, like the Americans have done, and enlist and increase the activities of the Agricultural Department in enlarging the resources of the cultivator and thus build our educational system on the increased prosperity of the agricultural classes? These are the questions I desire to offer for consideration. India is in no better position than the Southern States were ten years ago. Indeed I think we may safely assert it is in a far worse position. The average earnings of individuals in the Southern States at that time were 150 dollars. In India, according to some authorities, under the most optimistic calculations, they are as low as Rs. 30 per head. You must agree this gives little or no scope for self-help. It therefore seems to me plain that under present conditions we cannot expect the country to supply itself with the means for an advanced system of education. Nor can Government be expected to do so, for Government's resources are limited and depend upon taxation, and that in turn depends upon the ability of the people to be taxed. All Government can do is merely to touch the fringe of the problem and supply a modicum of education; it cannot afford to do more. Mr. Fremantle very well describes the situation when he says: "We

should surely pause to consider whether the time is ripe for the introduction of a system of general primary education into rural areas. It is a question whether we are not beginning at the wrong end and whether primary education can make any real advance before there is a substantial improvement in economic conditions."[1] These are words which the devotees at the shrine of the policy of free education for the masses might with advantage ponder.

The question then is whether we can, in any way, make the principles which have been so successfully applied in America, applicable to India. My belief is that we can. We have practically the same conditions here as obtained in the Southern States ten years ago. If anything, as I have shown, they are a good deal worse. But this is no argument against their adoption. Rather the reverse, for the lower the degree of prosperity, the greater is the need for increasing it. Already in the Provinces a great deal has been done by the Agricultural Department in the way of demonstration of the character described and utilized by the American Board of Education. But it does not go far enough. It, however, forms a nucleus on which to expand and might well be used as a beginning. The work is on the right lines. But we require to do more. We want more men, more money, wider organization; but, above all, we require the recognition amongst all classes that in this work lies the germ of future progress. This is a point which is not generally recognized, or, if so, it is certainly not acted upon. While the money spent to-day on education is over 10 crores of rupees, that on agricultural development is only 50 lakhs. That shows that we have not yet got to view these two important problems in their right perspective, and do not fully realize the important relation which agriculture bears to education. Many think that the development of agriculture depends on education, and we gave effect to that view when we started our agricultural colleges. But would it not seem that the truth lies in the opposite direction, and that in a backward country like India the advance of education is really dependent on the development of agriculture, and that the best form of education

[1] "A Policy of Rural Education," W. Newman & Co., Calcutta.

you can give to the rural classes under existing circumstances is demonstration in improved agricultural methods? It was found to be so in the Southern States of America and we have no reason to suppose it is otherwise in India. To carry out the idea it is not necessary to bring our present educational policy to an end. I would not propose anything so revolutionary. Government must, as I have already explained, supply a modicum of literary teaching and this must continue, but it would be an immense improvement if the Agricultural Department were called in to co-operate and demonstration were given a large share in the general scheme of education.

We could not be expected at first to progress with the same degree of rapidity as in America, because we have to do a large amount of research and experiment before we can demonstrate improved methods on a large scale. In America the advanced stage in the agricultural development of the Northern States supplied ready at hand the stock-in-trade required for at once setting in motion the demonstration movement in the backward Southern States. We are not so forward. Still we have achieved enough with our small band of workers to show that the same kind of work can be done out here and that all we require is expansion. Given the means for this (and who will say it would be a bad investment?) and a recognition of demonstration as an integral part of a general scheme of education, and I feel sure we shall, by such a policy, lay the best and securest foundations for the advancement of education as well as of the prosperity of the people.

THE APPLICATION OF BOTANICAL SCIENCE TO AGRICULTURE.

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I. Introduction.

A study of the literature dealing with agriculture indicates that there is some confusion of ideas as to the precise relation which exists between the science of botany on the one hand and the practice of agriculture on the other. In the present paper, an attempt has been made to define the bearing of the scientific aspect of the vegetable kingdom on the economic development of crop-production and to show how a knowledge of this science can best be applied to agricultural problems. A new term has recently grown up—Agricultural Botany—and text-books have appeared thereon as if a new branch of the science had been developed. Agricultural botany is supposed to be easier than ordinary botany and to be more adapted to the needs of the students in agricultural colleges. It is often assumed that in such colleges only a rudimentary knowledge of botany is required and that the examples used in teaching must of necessity be taken from cultivated crops. It is even thought that students trained in this manner will develop into investigators and that advances in agriculture can be achieved by such agency. I venture to assert that nothing could be further from the truth and that, in this direction, there is no royal road to success and that the final result of such endeavours can only be disappointment. For any real advance to be made in crop-production, a thorough scientific knowledge of botany in all its branches is one of the first

conditions of progress. This will be clear if the real problems to be solved are considered in all their bearings.

The attempt to improve cultivated crops by scientific methods is a recent development and can be traced to two main causes—(1) the gradual recognition of the fact that in agriculture the plant is the centre of the subject; and (2) the rapid rise of the study of genetics which followed the re-discovery of Mendel's results in inheritance.

Starting from Liebig's application of chemistry to agriculture, an enormous amount of chemical investigation, relating to the composition of the soil and of the plant, took place and for a time great hopes were entertained that in this direction important progress could be made. These expectations were not fulfilled, and gradually the chemists broadened the basis of their investigations and took into consideration the physical character of the soil, its geological origin, and the natural vegetation found growing therein. In this manner, modern soil-surveys have arisen in which the importance of the plant as a living organism has been slowly recognized. Recently, the development of genetics has drawn still more attention to the plant and this recognition is reflected in the present constitution of the staffs of up-to-date Experiment Stations. Side by side with these changes, the studies of disease in plants have to some extent receded in importance as is well seen if the present staff of the Bureau of Plant Industry of the United States Department of Agriculture is compared with that of twenty years ago when this Bureau was almost entirely composed of mycologists and when the advice given by the botanists was largely confined to the treatment of plant diseases.

The importance of the plant in crop-production may be said to be generally recognized at the present time. A large number of botanists are being employed at Experiment Stations and the public have often been led to expect that a revolution is about to take place, particularly through the application of what is popularly known as Mendelism. A critical examination of the literature discloses some signs that these extravagant hopes are not likely to be fulfilled, not that these hopes are impossible but rather because the problems

have not always been taken up on a sufficiently broad basis and attacked simultaneously from several standpoints.

II. The Development of Botany.

A brief review of the manner in which botanical science has developed will help to make clear the great difficulties which must first be surmounted before any results of real practical value can be obtained.

As is well known, the origins of modern botany are to be traced to the old herbals of the sixteenth and seventeenth centuries and to a period when plants were studied chiefly from the medicinal point of view. It was then essentially a field study out of which the modern ideas on classification slowly emerged. The development of the microscope, while leading to immediate and far-reaching advances, necessarily focussed the attention of investigators on the anatomy of plant organs and on the study of the various structures met with in these researches. Similar particularist tendencies arose in the growth of systematic botany and undue attention was often paid to the study of the floras of various regions from the point of view of herbarium specimens alone. The growth of physiology was too slow to remove entirely the evils of a somewhat formal and one-sided development which was reflected both in teaching and research. Physiological investigations are notoriously difficult and the greatest patience and skill are necessary in advancing our knowledge of the various functions in the plant. The manner in which botanical science has developed and the necessity of dealing with large classes of students in Universities, have necessitated a somewhat formal presentation of the subject in separate sections such as morphology, anatomy, physiology, and systematy. Much of this sub-division is inevitable but it renders difficult a proper conception of the plant as a living whole, as a complex factory which takes in, by way of the roots, various mineral salts in solution in water and, by the leaves, oxygen and carbon dioxide from the air, working all these raw materials up into complex food substances by means of energy focussed from the sun through the medium of the chlorophyl corpuscles. The plant is continually manufacturing

new food, developing new organs, and completing its life cycle under constantly varying conditions as regards moisture, food materials, temperature, humidity, and illumination. The vegetable kingdom is like a multitude of exceedingly complicated and competing hostile factories which have to carry on their activities under all sorts of rapidly varying circumstances. Any failure to meet the changes in the working conditions, caused by weather or by shortage of water and mineral salts in the soil, may mean the stoppage of the factory and the extinction of the organism. In this competition, all the combatants are armed to the teeth and possess all kinds of devices to assist in the struggle for existence. If any space in the sun is yielded by one of the competing factories, it is instantly seized by the rest. The limitation of armaments is an impossible conception in the vegetable kingdom. It is no easy task for the student to appreciate fully the many-sided aspects of the living plant and to master the manifold details of a science, still to a large extent in the descriptive phase of development, particularly when that subject is presented to him in parts often very loosely bound together. The investigator too is hampered in this direction by the necessity of specialization and of narrowing down the conditions of a problem so that the ordinary clear cut methods of academic research can be applied. It requires a conscious mental effort on the part of a botanist to regard the vegetable kingdom as a whole and not to think of it only in terms of systematy, physiology, or of anatomy. Training in research in any particular branch does not necessarily widen the general outlook, although it is of the greatest use in other ways.

The more recent developments in botanical science are fortunately all tending to a study of the plant as a living whole. Both the scientific study in the field of plant associations (ecology) and the systematic examination of the various generations of plants raised from parents which breed true (genetics) are doing much to mitigate the evils which follow from undue devotion to purely laboratory work. Ecology and genetics are taking the botanist into the field and will, in all probability, materially influence the future development of the science. This will be all to the good and

should do much both to raise the standard of and emphasize the importance of field work and also develop the natural history side of botany. The botany of the future is likely to combine all that is valuable in laboratory work with modern ideas on ecology, classification, and genetics.

III. The Relation of Botany to Agriculture.

We have seen that from the nature of the subject and arising out of their training, most botanists experience difficulty in realizing fully the plant as a living whole in which one part reacts on another. A wide scientific outlook on the many aspects of plant life is nevertheless the first condition in applying botanical science to practical problems. It is, however, by no means the only one. The next step for the botanist is to study his crop in the field and to learn to appreciate the agricultural aspects of crop-production. In other words, he must study the art of agriculture as applied to his particular problem. Too much stress cannot be laid on this. The investigator must himself be able to grow his crop to perfection and it is not too much to say that no real progress can be made without this. The ordinary agricultural processes applied to any crop bear a direct relationship to the physiological necessities of the plant and have been evolved from centuries of traditional experience. Thus in the growth of *rahar* (*Cajanus indicus*) in many parts of India, it is the custom to dig the land at the end of the monsoon as by this means the yield is increased. The physiological basis of this operation is the necessity for the provision of abundant air for the root-nodules in an alluvial soil consolidated by heavy monsoon rainfall. Indeed the agricultural processes necessary to grow a crop to perfection in India are nothing more than lessons in physiology learnt by experience through a long period of time. In all investigations on crops, a first-hand knowledge of practice is necessary and nowhere is it so important as in plant-breeding work where practice is quite as valuable as an acquaintance with the methods and results of genetics. The greatest devotion to the study of inheritance, using for this purpose material indifferently grown, is largely labour lost as many characters are masked unless the plants are really

thriving and well-developed. For instance in wheat, the red colour of the chaff never develops in badly grown plants thereby causing great confusion in systematic and breeding work on this crop. In tobacco, the various leaf characters are almost entirely masked by bad cultivation and their inheritance can only be studied if the crop is grown to perfection.

The investigator, after having learnt how to grow plants and having mastered agriculture as an art, must proceed to study his crops in the field. It is not sufficient to plant the seed and wait till flowering time and harvest come round for the results. Daily contemplation of the growing crop and observation of the plant through its whole life-history will suggest many new ideas and do much to train the observer, and develop the power of accurate deduction and real agricultural insight. In variety trials and field experiments, the necessity of constant observation of the growing crop is seldom recognized. An even plot of land is selected, the crop is sown and the harvest weighed. Should the season be abnormal, this circumstance is often recorded. It is somewhat dimly perceived that the quantitative results of any year partake of the nature of an accident, but it is thought that a repetition of the experiment for, say, fifty to one hundred years and the striking of an average result will remove most of the effects of disturbing factors. It is true that this expensive and time-consuming procedure will give the mean result under the conditions of the experiment provided all due care is taken in carrying out the work. On the other hand, a constant observation of the growing crop by a fully qualified observer will lead to the deduction of the factors on which yield depends far more rapidly and accurately than can be done by such a mechanical method. Constant observation of the growing crop is therefore of the first importance. In course of time, the observer learns how to read his practice in the plant and, at the same time, he develops from hardly won experience a sympathy and understanding of the cultivator and of the grower's point of view. The raising of crops is a most useful discipline for a young investigator fresh from the university, and it also serves rapidly to remove any intellectual arrogance he may possess in his attitude

towards the farmer or cultivator. First-hand practical experience will thus assist towards producing a proper relationship between the scientist on the one hand, and the practical man on the other. This apprenticeship will, at the same time, serve to eliminate at the outset men who lack a practical turn of mind. The agricultural public judges largely by eye, and is not trained in the rapid digestion and understanding of printed reports. Well grown crops at an experiment station are much more telling than printed bulletins however well-illustrated these may be. In dealing with the would-be improver, the attitude of the agriculturist is often one of amused scepticism as, among themselves, deeds always count much more than words and the benefits of education are not always regarded with enthusiasm. "Show me thy cultivation and I will tell thee what thou art" is merely putting into words the view of the countryside towards a new arrival in its midst. The agricultural investigator must also pass through this ordeal with credit to himself before he can hope to establish his position and hold his own with the tillers of the soil.

Science and practice must be combined in the investigator who must himself strike a correct balance between the two. The ideal point of view of the improver is to recognize agriculture as an art which can best be developed by that instrument called science. Once this is fully realized and acted upon, the place of the experiment station in agriculture will be understood as a matter of course and the qualifications needed by the workers will be self-evident. There will be little or no progress if practical agriculturists are associated with pure scientists in economic investigations. This has often been tried and has never yielded results of any importance. The reason why such co-operation fails is that without an appreciation of practice, the scientist himself never gets to the real heart of the problem. The history of the indigo investigations in India is a very good case in point. During the last 20 years, a number of scientists have been employed in an endeavour to improve the production of natural indigo. Over £50,000 have been expended on this work between 1898 and 1913 but no results have been obtained, largely because the scientists preferred to engage European

assistants on indigo estates to grow their experimental crops rather than to cultivate them themselves. The result was that the real problems were not discovered, a large amount of ineffective work was done and valuable time was lost during which the natural indigo industry declined and the synthetic product rapidly established itself in the markets of the world. The solution of the indigo problem has recently been disclosed by a study of the plant in the field. It is not too much to say that if a properly qualified botanist with a knowledge of agriculture had attacked the indigo problem twenty years ago, the history of this industry would have been very different.

There remains for consideration the commercial aspect of investigations on crops and the necessity, on the part of the worker, of keeping in close touch with the requirements of the trade. Particularly is this important in the case of materials used in textile industries like cotton where any marked alteration in the raw product might easily involve extensive changes in machinery. In the case of cereals like wheat, it is necessary in improving the variety to follow closely the needs of the manufacturer and to ensure that any new types introduced into general cultivation can be milled to advantage. If grain quality, of increased commercial value, can be secured as well as higher yielding power, the combination is all to the good. The investigator must therefore study trade requirements and be able to make use of the experience and knowledge of the men who handle and use produce on the large scale. The successful merchant often possesses information which is of the greatest value to the botanist and which helps the investigator to perceive the manner in which an improvement can most effectivel be made. Just as the success of a commercial man depends on his ability to determine the direction in which he can improve his method or his product above those of his competitors, so the investigator must possess a similar practical instinct. He must be able rapidly and unerringly to decide in which direction the maximum improvement is possible.

That a combination of science, practice, and business ability in the same individual is essential in all agricultural investigations

dealing with the plant will be evident if the kind of problem awaiting solution is considered in detail. Many of these questions fall into the following three classes :—

(1) *Improvements in the efficiency of the plant.* If we regard the plant as a factory and a crop as a number of factories, the aim of the grower is to produce the largest possible output of some plant product—seed, leaves, roots, stems, or flowers. In stimulating a crop to produce the maximum in any one direction, the factory as a whole must be considered and the machinery must not be thrown out of gear. The physiological aspects of growth must be clearly kept in mind as well as the conditions under which the translocation of reserve foodstuffs takes place. We can, for example, often increase the yield of leaf in a crop like tobacco by suitable manurial treatment such as a copious supply of nitrogenous food material, but the resulting loss in quality is so great that the extra weight would result in financial loss. We should merely produce in this way badly ripened leaves in which the proper development of colour and flavour during curing would be impossible. Any attempt to increase the output of a crop can only be successful if the physiology of the plant is considered together with the economic aspects of production. Such problems have to be solved within the working conditions of the plant factory and also within the general economic limits imposed by labour and capital. In such matters, the investigator might easily go astray unless he keeps the laws of plant physiology in view and unless he is fortified by a knowledge of practice and an appreciation of the general working conditions.

(2) *The treatment of disease.* The inadequacy of much of the experiment station work on the diseases of plants, in which fungi and insects are concerned, has recently been referred to by Professor Bateson[1] in one of the sectional addresses to the British Association :—

" Nowhere is the need for wide views of our problems more evident than in the study of plant diseases. Hitherto, this side

[1] *Report of the British Association for the Advancement of Science*, 1911, p. 590.

of agriculture and of horticulture, though full of possibilities for the introduction of scientific method, has been examined only in the crudest and most empirical fashion. To name the disease, to burn the affected plants, and to ply the crop with all the sprays and washes in succession ought not to be regarded as the utmost that science can attempt. There is at the present time hardly any comprehensive study of the morbid physiology of plants comparable with that which has been so greatly developed in application to animals. The nature of the resistance to disease, characteristic of so many varieties, and the methods by which it may be ensured, offer a most attractive field for research, but it is one in which the advance must be made by the development of pure science, and those who engage in it must be prepared for a long period of labour without ostensible practical results."

A diseased condition in a plant usually arises from some profound interference with the normal physiological processes after which a pathological phase gradually develops. The protoplasm and cell-sap become charged with waste products and a parasitic fungus is then able to destroy the tissues. An invasion of fungus mycelium is usually impossible when the plant is in health as protoplasm is strong enough to resist any attack and the cell-sap is not in a suitable condition to nourish the fungus. The parasitic fungus and the destructive insect are often consequences rather than the real causes of disease and are merely the last phase in the death of a moribund organism. The Java indigo crop in Bihar[1] has recently furnished an interesting example of the necessity of a wide outlook in the investigation and treatment of plant diseases. A diseased condition, known locally as *wilt*, began to make its appearance some years ago after which it rapidly spread all over Bihar. About the middle of the monsoon, the plants were observed to drop a good deal of leaf and the remaining foliage was seen to change in appearance, becoming a greyish, slaty colour. Growth finally ceased after which the plants slowly died during October and November. Not only was

[1] Howard and Howard, *The Improvement of Indigo in Bihar*, Bulletins 51 and 54, Agricultural Research Institute, Pusa.

the yield of dye seriously reduced, but the affected plants yielded hardly any seed. For this reason, the area under Java indigo in Bihar rapidly fell from 70,000 bighas in 1910 to about 15,000 bighas in 1913. Investigation of this disease yielded no results, and it was found that none of the insects, fungi, or bacteria associated with the affected plants were responsible for the trouble. For the moment, science seemed entirely at a loss in suggesting any practicable means by which the final extinction of the indigo industry could be prevented. In reality, however, the position was in no respect hopeless. Examination of the affected crop showed that the leaf-fall and wilt were connected with the destruction of the active root-system of the plant, including the nodules, as a result of interference with the air-supply of the roots brought about by a constantly wet condition of the soil during the long monsoon phase. The wilt disease was found to be the last stage in starvation caused by the cutting off of the supply of one of the essential raw materials—air—needed by the roots and root-nodules. Evidently the line of attack lay in the direction of increasing the air-supply in the soil and in assisting the plant to withstand the constantly moist soil conditions which set in during the monsoon. This was done by improving the methods of cultivation during the hot weather and by the provision of surface drainage, by which each field was cut off from the run-off of other areas by a suitable arrangement of trenches. The problem of the seed supply was solved by August sowings on high-lying, well-drained fields. In this manner, the plants were able to withstand the wet soil conditions of the second half of the monsoon without injury and to yield fine crops of excellent seed. The yield of dye was materially increased by thorough cultivation in the hot weather combined with surface drainage. The history of the indigo disease in Bihar furnishes a very good example of the necessity of a broad outlook in dealing with diseases of crops and for regarding the plant as a complex factory in which injury to any one part often upsets the whole machinery.

(3) *The creation of improved varieties.* In the development of an industry like the manufacture of cotton cloth from the raw material, there is, as is well known, a constant substitution of the

existing machinery by improved types and the scrapping of old plant is continually taking place. In like manner in agricultural development, the substitution of existing varieties by improved forms is constantly being carried out, and in many European crops the varieties grown a hundred years ago have almost disappeared. In crop-production, as in cotton factories, the size of the scrap-heap is one of the indications of the rate of progress. The creator of new varieties of plants must obviously be even better fitted for his task than the engineer who improves spinning and weaving machinery. In a cotton factory, improvement can be made in detail whereas, in the plant, the whole factory must be replaced by a new one and the variety changed. To develop an improved variety and to utilize botanical science to the best advantage, it is clear that the problem to be attacked must first be understood in all its bearings. We require to know by experience the general agricultural conditions of the tract in which the improved variety is to be grown, the kinds at present cultivated, the directions in which improvements are possible, and where the greatest economic advantage can be obtained. In other words, the problem must be simultaneously considered both from the standpoint of the cultivator and from the point of view of the trade. An understanding of the needs of the crop and a knowledge of systematy and genetics must be combined with the insight of the inventor. In such work, no possible scientific method can succeed without the intuition of the breeder. Any attempt to measure or record the characters of large numbers of plants and to obtain the final selections by a scientific system of marks is hopeless, as the investigator would be speedily swamped by the volume of his material. The insight of the breeder is necessary for the work and the judgment, which comes by practice, in the rapid summing up of essentials by eye is far more useful than the most carefully compiled records or any system of score cards. The successful plant breeder is to a large extent born and not made as is proved by the fact that without the aid of science great advances have been made in the breeding of stock, cereals, and in various branches of horticulture. Science helps the born breeder by providing him with new and better instruments and, by bringing knowledge to bear

from many sides, it accelerates the output and lightens the work in a multitude of ways.

In the limits of this paper, an attempt has been made to indicate the class of problems in plant-production which await solution if progress in agriculture is to be obtained by the aid of botanical science. These problems are not simple, and often cannot be solved by the ordinary methods of academic research. Many of them can, however, be dealt with successfully if attacked simultaneously from several standpoints provided always that the investigators themselves are fully qualified for the work. As far as crops are concerned, progress can best be made by botanists, well grounded in pure science, who, at the same time, possess sufficient aptitude to master agriculture as an art and who also have the type of mind to be found in the successful inventor. In this direction, the field of work in the Empire is almost unlimited and the great universities, by helping to train the investigators of the coming generation, have a truly Imperial task to perform. Failure on the part of individuals will occur in the future as in the past, but one great cause of want of success will be removed if the all-importance of agriculture as an art in the equipment of the next generation of experiment station workers is recognized by all concerned. The State can do much in these matters by a practical recognition of the principle that the labourer is worthy of his hire and that the man, who makes two blades of grass grow where one grew before, deserves well of his country, and must be promptly and adequately remunerated.

IMPORTANCE OF SOIL-AERATION IN FORESTRY

BY

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FOREST officers have long realized the importance of soil-aeration in Forestry in so far as this is connoted by such general expressions as "the physical condition of the soil," "water-logging," and so forth. The aspect of this question dealt with in the present paper, however, is one which has not yet attracted the attention it deserves, *viz.*, the damage that may be done to the seedlings of our forest trees by insufficient soil-aeration when the physical condition of the soil is apparently suitable for growth and when the soil, although moist, is far from being saturated with water. The results noted in this paper refer, it is true, to a single species only, *viz.*, the *sal* tree, *Shorea robusta*, but it is believed that they will be found to apply to a number of other species.

The seedling reproduction of *sal* in our Indian forests is by no means satisfactory. In many forests where conditions seem favourable no seedlings exist, and in others the seedlings die back for several years. Plate I, fiig. 1 shows examples of *sal* seedlings which have died back for several years and which are typical of the majority of those found in the protected forests of Northern India. Note the thickened rootstocks and comparatively feeble shoot development. This dying back is usually considered to be due to drought. The whole plant here dies annually with the exception of the stout portion just below the ground level which persists and gradually increases in size and length until finally a persistent aerial shoot is also developed. This delay in the establishment of seedlings interferes with the economic management of our forests and entails a financial

sacrifice in the loss of several years' increment. Drought, however, obviously cannot explain why seedlings frequently die wholesale during the rains nor why the dying-back is frequently more marked in the moist soil of the shady forest than in the drier soil in the open.

The following results dealing with the causes of the death and dying-back of *sal* seedlings have now been established by work recently carried out at Dehra Dun :—

(1) Seedlings grown under favourable conditions of soil and moisture in the Dehra garden do not, as a rule, die back. A few weakly individuals do die back, but the majority produce vigorous shoots which persist from the first and attain an average height of 13″ in one year and 26″ in two years.

Plate I, fig. 2 shows such seedlings one year old and also some weakly plants of the same age which have died back. These vigorous garden plants indicated the development which was possible under the local climatic conditions and the chief object of the present work was to attain or approach this ideal in the local forests.

(2) An experiment carried out in the Dehra garden, in 1913, showed that, if rain water was allowed to accumulate in non-porous pots, in which the basal drainage holes were tightly corked, and which were filled with the local *sal*-forest soil, the latter was soon rendered entirely unsuitable for the growth of *sal* seedlings, although it was by no means saturated with water. It was found that, under these conditions, 100 per cent. of *sal* seedlings were either killed or had their roots extensively rotted when the water-free air-space in contact with their roots was maintained at 450 c. ins. per c. ft. of soil, or less, for a period of 6 weeks, while seedlings in the same soil, in similar pots, but which were uncorked, remained healthy. This experiment was repeated in 1915 with practically the same results.

Plate II shows the appearance of the seedlings in these pots in September 1915. Note the healthy plants

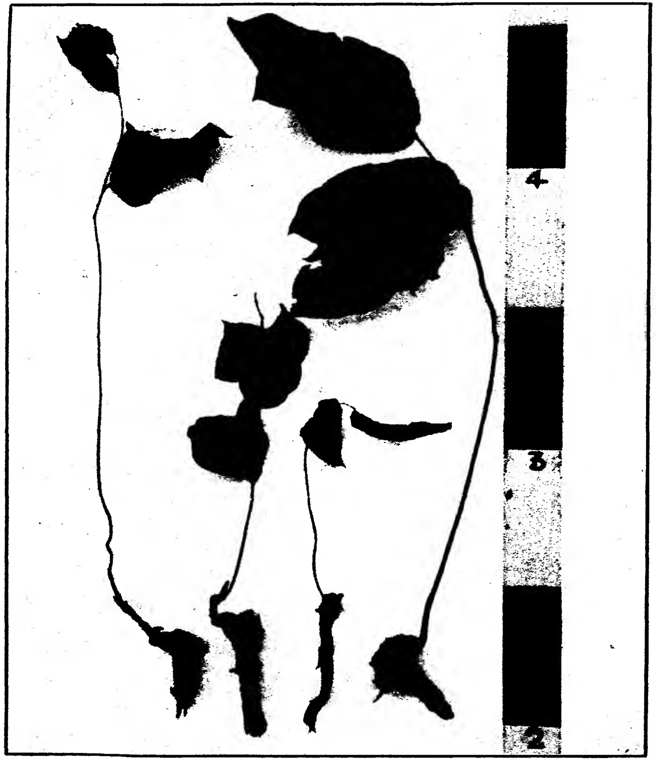
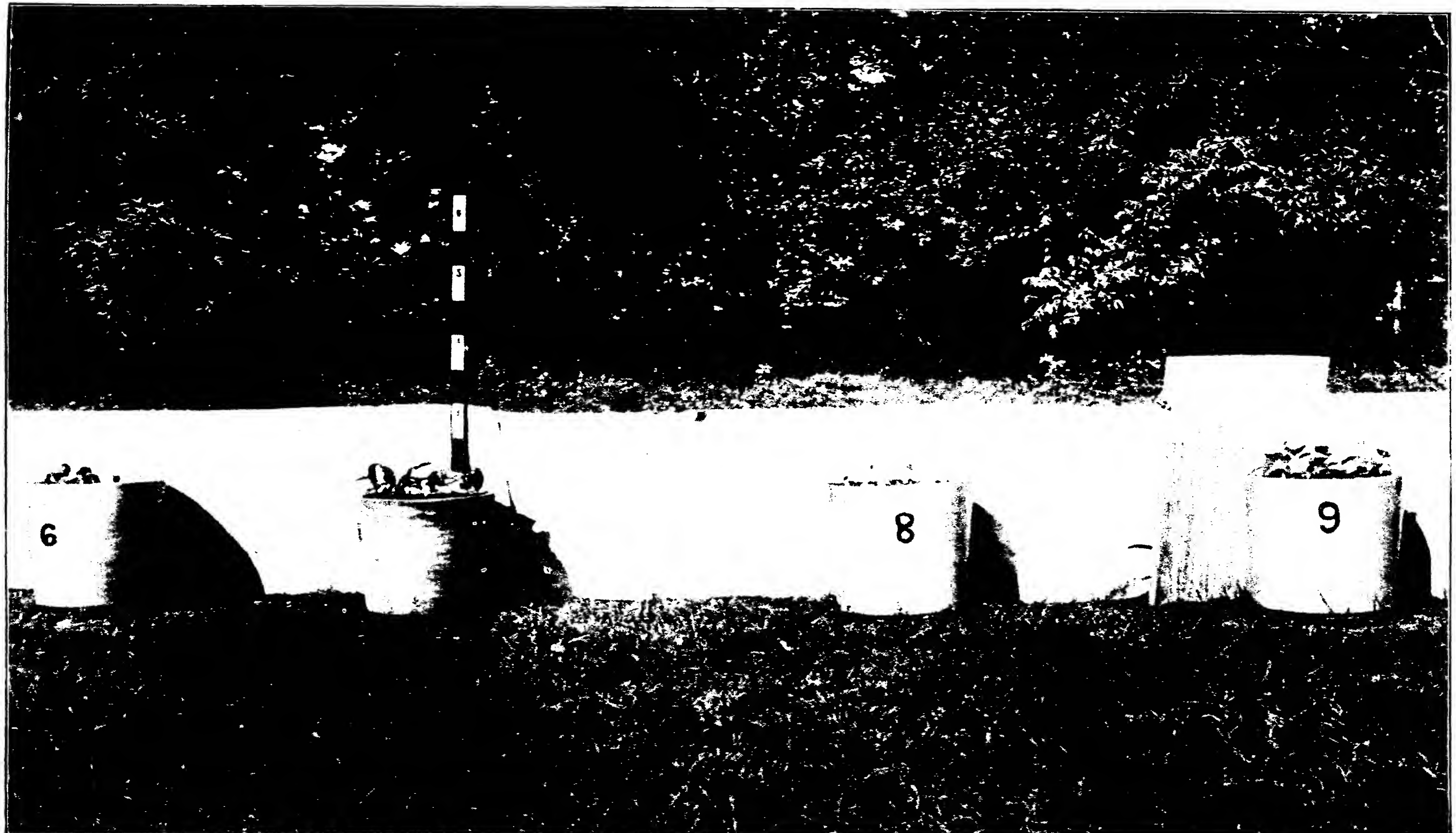


Fig. 1.

Sal seedlings typical of those found in the protected Dehra Dun forests. These have greatly thickened rootstocks and have died back for several years. The measuring staff appearing in this and the subsequent figures shows lengths of 6 inches, alternately black and white.

Fig. 2.

Sal seedlings, 1 year-old, grown under favourable conditions of soil and moisture in Dehra Dun Experimental Garden. The five small plants have died back. The majority of the plants, however, do not die back under these conditions and the four large specimens are typical of these. Such vigorous plants attain an average height of 13. 6 inches, in 1 year and 26 inches, in 2 years. This may be regarded as the ideal seedling development possible in the locality.



Photograph taken 20th September 1915, showing *Sal* seedlings growing in *Sal* forest loam. Note the healthy growth in the uncorked pots 7 and 9, as compared with that in pots 6 and 8 which were corked on 30th July 1915.

in the uncorked pots 7 and 9 as compared with those in the corked pots 6 and 8.

This strongly injurious effect on *sal* seedlings of a constantly moist condition in loam was also obtained in an earlier experiment in which good basal drainage was provided, but in which the soil was kept constantly moist by merely diminishing the evaporation from the surface.

(3) Sowings in 1912-13 in sample plots in the shade of the local *sal* forests and on similar soil in the open outside the forests, respectively, resulted at the end of the first rains in 7 per cent. and 37 per cent., respectively, of healthy plants, calculated on the number of seeds sown. Similar sowings in the following year resulted in 17 per cent. and 86 per cent., respectively, of healthy plants. In these experiments the death of the large number of seedlings in the shade was preceded by more or less extensive rotting of the root. During the rains of 1912 the surface soil of the shade plots did not contain more than 400 c. ins. of water-free air-space per c. ft. of soil, whereas the soil of the open plots contained considerably less water and more water-free air-space. It will also be seen that, in the shade plots, the water-free air-space was actually less than has been proved to be highly injurious in the same soil in non-porous pots. In the dry season following the rains of 1912 more seedlings died of drought, during the months of least rainfall, in the shade than in the open plots. This was explained by the fact that, although there was practically no difference in the soil-water-content of the open and shade plots, respectively, at a depth of 3–9″ during this period, the roots in the shade had attained, by May 1913, an average length of 6″ only, as against an average length of 18″ in the open. The plants in the open, therefore, having their roots in the deeper moister soil layers were comparatively safe from damage by drought.

Plate III, fig. 1 shows a typical shade plot at the close of this experiment in July 1915. Notice the absence of vigorous seedlings in the seed-bed. Plate III, fig. 2, on the other hand, shows one of the open plots in the same month. Note the numerous healthy plants.

(4) Sowings, in 1913, in large pots filled, some with clean sand alone and others with a mixture of clean sand and dead *sal* leaves, which were sunk in one of the shade plots of the previous experiment resulted in a percentage of 82 healthy plants at the close of the first rains, as compared with 62 per cent. obtained in the adjacent soil from which the dead leaves and humus had been cleared for two years and 16 per cent. obtained in the same soil with which dead *sal* leaves had been mixed. The root development in the sand was also materially better than that in the adjacent soil. As the plants, in this experiment, were exposed to practically identical conditions of light, temperature, and air-humidity, this indicates that the unsatisfactory development of seedlings in the shady forest is primarily due to a soil factor and not to deficient light, unsuitable air-temperature, or air-humidity; also that the injurious effect is increased by an admixture of dead *sal* leaves with the forest soil and is inoperative in a well drained sand even when dead *sal* leaves are mixed with it. Other experiments have indicated that the effect of this soil factor is progressively diminished by repeated working of the soil coupled with removal of the humus.

With reference to the chief object of the present work, *viz.*, the establishment of vigorous seedlings in the local forests, the experiments detailed above indicated :—

(1) that an injurious soil factor was chiefly responsible for the unsatisfactory seedling development by causing high mortality during the rains and subsequently a high percentage of deaths from drought owing to poor root development;

Fig. 1.

Forest shade plot XI. Photograph taken 20th July 1915. 2 years after sowing. Note the absence of vigorous seedlings in the seed-bed.

Fig. 2.

Forest plot VIII. in the open. Photograph taken 20th July 1915. Note the numerous healthy 2-years-old seedlings surviving in the plot.

(2) that this soil factor could be put out of action by sufficiently good soil-aeration.

It appeared probable, therefore, that clearing the forest growth and exposing the soil freely to sun and air would produce the soil conditions necessary for successful growth, provided that the area cleared was sufficiently small to ensure the light side-shade necessary in Northern India for protection from frost. In 1913, therefore, two adjacent sample plots were selected in a portion of the Dehra forests where sowings in the previous year had given unsatisfactory results.

Above one plot, the overhead cover was entirely removed, before sowing, by felling all trees above and in the immediate neighbourhood of the plot, the total cleared space having a diameter of 60 ft. or a little less than the height of the surrounding trees. In the adjacent shade plot the cover was kept intact. At the close of two years, the percentage of healthy plants in the shaded and cleared plot, respectively, was 34 and 59, the percentage of the surviving plants which had not died back was 10 and 25, while the average height of the plants was 5″ and 12·4″, respectively. The fact that the ground was worked and dead leaves removed for two years in succession was responsible for the results in the shade being considerably better than usual, but there can be no question as to the marked superiority of the open plot. In the cleared plot also, taking only the 4 best plants (which would be sufficient to stock the area of the plot, *viz.*, 18′ × 3′), their average height was 20½″ which fairly closely approaches the ideal seedling development for the locality which was noted at the beginning of this paper *viz.*, 26″.

Plate IV, fig. 1 shows the shade plot and Plate IV, fig. 2 the cleared plot at the close of this experiment in July 1915.

The conditions necessary for the successful growth of *sal* seedlings, therefore, may be said to have been determined as follows:—

(1) a well aerated seed-bed free of raw humus;

(2) full overhead light;

(3) light side-shade sufficient to prevent damage from frost and to keep the soil moist in the dry season.

As regards the identity of the injurious soil factor alluded to, all the facts hitherto ascertained indicate that it can be rendered

innocuous by sufficiently good soil-aeration and, for the present, it may be conveniently indicated by the general term bad soil-aeration. It is not at present possible to define it more exactly or to indicate the precise way in which good aeration renders it innocuous. One thing, however, is clear, *viz.*, that the injurious action is not due merely to an excess of water in the neighbourhood of the roots. This has been praved by a water-culture experiment carried out at Dehra Dun during last rains, in which the injurious factor was found to be practically inoperative. In this case, after 75—78 days in the water-culture, only 8 per cent. of the *sal* seedlings died and the average length of healthy root in the surviving plants was 5·9." A simultaneous culture in badly aerated soil for a period of only 67 days resulted in 93 per cent. of deaths and an average length of healthy root of 1" only. Plate V, fig. 1 shows the appearance of the seedlings after 75—78 days in the water-culture and Plate V, fig. 2 shows the root-development of 6 typical specimens.

Other factors possibly concerned are the lack of sufficient oxygen for root respiration and the production and accumulation in injurious quantities in the soil of one or more substances which are directly poisonous to the roots. Further work is required to determine the relative importance of these factors. In the meantime, however, it is interesting to note that Mr. C. M. Hutchinson, Imperial Agricultural Bacteriologist at Pusa, who kindly examined samples of the soils from the corked pots mentioned in the above experiments, has found bacterio-toxins in all of them. These toxins are said to be capable of inhibiting nitrification and of directly injuring seedlings.

In conclusion, it may be noted that the accurate identification of this soil-factor is important for Indian Forestry, not only on account of its effect on seedlings, but also because of its possible action on older trees. There is reason to believe, for example, that, in the wet *sal* forests of Assam and the Bengal Duars which enjoy an annual rainfall of some 200", the intensity of this injurious factor progressively increases with the age of the forest and materially affects the health of the older trees—possibly preparing the way for the attacks of injurious soil fungi and other parasites.

Fig. 1.

Forest shade plot V. Photograph taken 20th July 1915. Note the appearance of the 2-years-old seedlings surviving in the plot.

Fig. 2.

Forest Plot IV. An area 60 ft. in diameter was here clear-felled in May, 1913. The photograph was taken on 20th July 1915. Note the vigorous 2-years-old seedlings surviving in the plot.

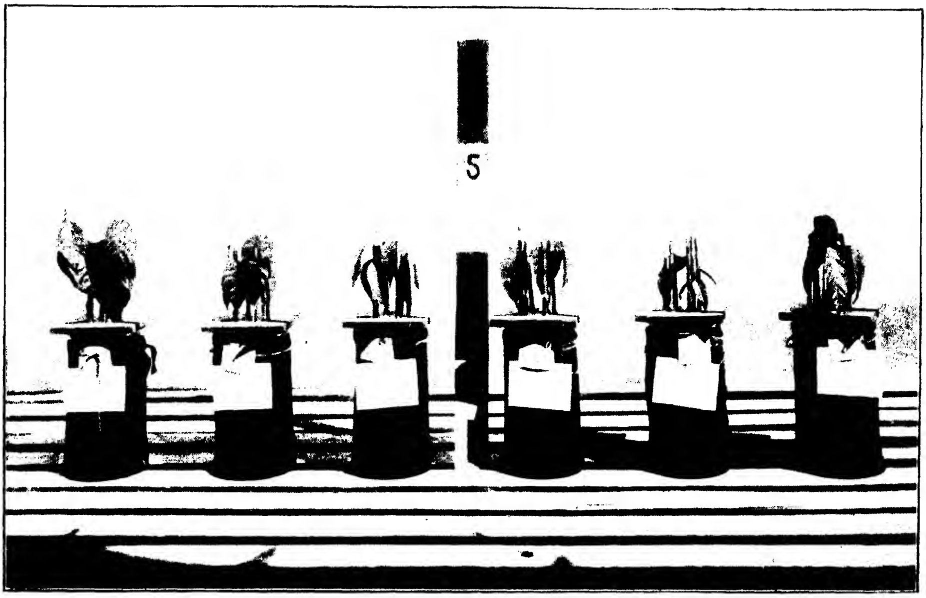


Fig. 1.

Photograph taken 27th October 1915, showing 12 *Sal* seedlings which have been grown continuously in a water-culture solution for a period of 75 (in the case of four plants on the right) to 78 days (in the case of 8 plants on the left.)

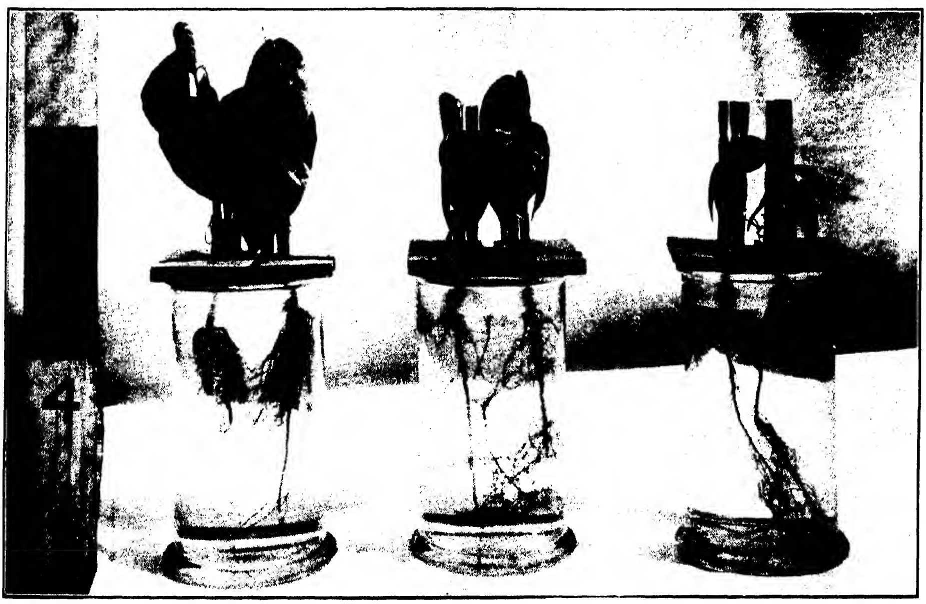


Fig. 2.

Photograph taken 27th October 1915, showing the root-development of 6 *Sal* seedlings which have been grown continuously in a water-culture solution for 78 days, in the case of the 4 plants on the left, and for 75 days, in the case of the 2 smaller plants on the right.

THE RE-ALIGNMENT OF AGRICULTURAL HOLDINGS

BY

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Most countries with a large peasant population have found it necessary at some time or other to introduce legislation for the re-alignment of holdings to enable the available land to be more economically and efficiently cultivated. The subject has been ventilated from time to time in India but little has been done. It is true that the waste of irrigation water, caused by the present hap-hazard system, has often been insisted upon, and in the Punjab care has been taken to avoid this on the great new canal systems. Near Poona in the Bombay Presidency the Irrigation Department is now engaged on the squaring up of fields and the drafting of rules to enable greater economy of distribution to be effected on the small, but important, canal systems which are chiefly used for sugarcane. Generally speaking, however, the advocate of re-striping is looked upon as an impatient idealist whose methodical soul is vexed by the present irregular field boundaries.

It has to be admitted that there are great practical obstacles in the way. The present land tenure system of the United Provinces, especially in that portion which comes under the Agra Tenancy Act, makes it exceedingly difficult to alter field boundaries without infringing vested interests. An occupancy tenant possesses cultivating rights in a definite plot of land, which may be only a fraction of an acre in area, and not only can he not be dispossessed, but there is no legal way in which his occupancy rights can be purchased from

him except in those cases where land is acquired by Government. Nor is the ownership of land any more simple. Many villages are now owned by a number of petty zamindars whose land is scattered in different parts of the village, so that any arrangement for general betterment by consent is practically impossible. It is obvious, therefore, that progress in this direction could only be made with the aid of special legislation.

The natural obstacles being what they are it is essential to show that the economic benefits to be derived from re-striping are such as to justify the necessary measures. It may be noted, however, in passing, that the present situation is largely the result of legislation undertaken within the last fifty years. The whole of the Indian land tenure system is based on the assumption that all land is the property of the state. The present system of landlords, with the private ownership of land, is a comparatively recent creation following on British rule and based on English analogies. Introduced as it was to save the agriculture of the country from the evils of the system of farming out blocks of land to contractors for the collection of revenue, it has largely justified itself, and the same may be said to be true of the tenancy laws which were introduced to further protect the tenant. It is only natural, however, that legislation introduced to meet pressing political needs should fail to take account of the effect on subsequent economic development. Should it be found that the tenancy laws in their present form are creating a new evil by checking economic development a strong case for their further modification would exist.

The present scattering of parts of a holding in different parts of the village, which is perhaps one of the first things which strikes the student accustomed to the compact farms of the west, is largely a result of the existing scheme of village life. Instead of each tenant residing on his holding it is usual to find all living in a central *basti*, even if it involves journeys of two or three miles for himself and his cattle. The system is wasteful of labour and cattle power and also of manure but has certain advantages. It doubtless arose when the mutual protection of life and property was more essential than at present, but it is unlikely that the present social organization

will be greatly disturbed in the near future, though signs are not wanting of a steady tendency to form smaller sub-villages nearer to the fields. While it is doubtless of some advantage to the individual tenant to have his holding spread over the different classes of available land, the system suffers from the disadvantage that there is less encouragement for a cultivator to concentrate attention on handling one class of soil adequately. Were this, however, the only point to be gained by the re-alignment of holdings one would be inclined to allow it to come about gradually as the result of changing social and economic conditions.

The greatest disadvantage of the present system, however, is that it prevents any tract of land from being treated as a whole and general measures taken for its improvement. The greatest limiting factor in Indian agriculture is undoubtedly the water-supply, and it is extremely difficult to take steps to improve existing conditions with the present system of holdings. In canal-irrigated tracts the area irrigated is almost invariably much less than the area commanded by the canal. The main great irrigation sources of the Province have already been harnessed and further development must either take the form of better economy in the use of the existing sources or the exploitation of schemes involving greater working cost and often higher capital expenditure and, therefore, more expensive water. It is commonly accepted that, from the great canals only about one-third of the water reaches the field, and that while some margin exists for the reduction of the amount of water actually applied the main losses occur in the canal channels and in the subsidiary village channels –which share the loss fairly equally. The prevention of loss by seepage from canal channels is beyond the scope of the present paper, but it may be noted in passing that any radical measures in this direction must involve additional capital outlay and, therefore, either a rise in the canal rates or better utilization of the water. The loss in village channels is to a great extent avoidable. At present the village water courses follow field boundaries and are consequently unnecessarily long and tortuous and often undesirably aligned as regards levels. While steady improvement in this direction is being effected

through the influence of irrigation officers many of the worst cases cannot be touched. Nor is the situation appreciably better in tracts which depend on wells for their irrigation. The channels from these also are often unnecessarily long and devious, and the scattered ownership of the small fields often puts obstacles in the way of the construction of much needed wells. With more compact and better aligned holdings there would be a greater incentive to the construction of larger wells (or of tube wells) enabling a larger area to be irrigated with less labour. Recent experiments seem to indicate that there is a great future for the employment of oil engines and pumps both on the best masonry wells and on tube wells, but with holdings in their present form, economical distribution of the water is difficult and in many cases so many small interests are involved that it would be difficult to meet them all.

It would be easy to cite many other instances of indirect disadvantages for which irregular field boundaries are responsible, *e.g.*, the absence of decent roadways to give access to the fields, difficulties as regards threshing floors and the carriage of produce and manure, but it is sufficient to say here that they all share one feature, *viz.*, that, except in the case of works undertaken by Government, armed with the powers of the Land Acquisition Act, progress is almost impossible under present conditions.

It is now proposed to consider the effect of present conditions on the actual cultivation of the land. The maintenance of correct levels in a field during all processes of cultivation is recognized in most countries as one of the essentials of good farming. In the Gangetic plain, with an exceptionally easily worked soil, the results of carelessness in this direction are not so readily noticeable, but, on the other hand, the nature of the climate—characterized by heavy falls of rain confined to certain periods of the year and that (in the case of cold weather crops) not the growing season—makes the conservation of rain-water and its correct distribution on the land of vital importance. It being almost impossible to correctly plough a small irregular field, it is not surprising that most cultivators' fields show bad patches which are frequently due to nothing more than faulty levels. The lower patches are water-logged during

the monsoon while the higher patches dry out too quickly in the cold weather. Even the best cultivators' fields are frequently saucer-shaped, with the result that there is water-logging in the centre and consequently a poor crop. When any form of iron plough is used to improve the general cultivation, the difficulties are accentuated as the deeper and more thorough the cultivation, the greater the necessity for the maintenance of correct levels. Simple as it may seem, there are few agricultural officers who have not been confronted with this cause of loss of yield at some time or another. The explanation as to why even comparatively slight and temporary local water-logging causes serious loss is probably to be found in the fact that successful cultivation in the plains of India largely depends on the maintenance of a suitable environment for nitrogen-fixing and nitrifying organisms during the monsoon period. Local water-logging during the monsoon, producing temporarily anaerobic conditions, causes a loss of available nitrogen and hence a diminished crop. The experiments carried out by Mr. and Mrs. Howard at Pusa show that not only does the wheat crop on water-logged land yield far less than on properly drained land, but that the result can be partially remedied—but at additional cost—by the application of nitrates. Generally it may be said that the present small and irregular fields common in many parts of this province seriously militate against the adequate conservation of soil moisture and the maintenance of fertility and, therefore, cause direct loss of produce. Further, they discourage the introduction of the more expensive improved ploughs and cultivating implements as it is difficult to work these to advantage in small irregular fields, whereas if the fields were decently aligned there is reason to believe that joint ownership of such implements would be practicable.

In no direction, however, is the need for the re-striping of holdings more clearly seen than in the problems of checking erosion and effecting adequate drainage. The question has been fully dealt with by Howard[1] so that it is sufficient here to deal with its main aspects only. We are so accustomed to think of the plains of India as flat

[1] Howard, A. Soil Erosion and Surface Drainage. *Bulletin* No. 53 *of the Agricultural Research Institute, Pusa.*

that we are apt to overlook irregularities which, small as they are compared to the hill systems of other countries, are sufficient to be of a great importance in a country of heavy rainfall. As is pointed out by Howard comparatively gentle slopes are sufficient to allow large quantities of the finer particles to be removed from the higher lands to the lower with the result that the physical texture of both deteriorates. The high lands are annually denuded of their finer particles and the fertility and moisture-retaining capacity adversely affected. The low lands, constantly receiving the run-off from the high, are annually receiving unneeded additions of fine silt thus becoming heavier and less workable and in addition receive an excess of water preventing adequate cultivation in the rains and causing a direct loss of fertility. Figures are published in the Cawnpore Farm Report for 1915 which show that the introduction of suitable catch drains on an area of this type has made it possible to raise a normal good crop of wheat on land that a few years ago had to be thrown out of wheat cultivation on account of the water-logging that took place in the rains. On a larger scale the recently opened Kalianpur Farm provides an example of a piece of land, previously only barely culturable, which has been converted into a good farm by proper terracing and correct laying out; the capital value of the land, as judged by its yielding capacity, has trebled in about 5 years. Operations of this nature, however, require control over a considerable area. Given this control it would not be difficult, nor unduly expensive, after a proper survey to lay out most villages with proper drains and banks to stop erosion and prevent water-logging of the low areas, providing suitable roads, footpaths and proper irrigation channels. At Kalianpur indeed it was found possible to make the channels serve the double purpose of catch drains and irrigation channels. Under present conditions, however, it is impossible to carry out alterations of this kind unless the land is the property of Government or, in rare cases, of a single individual.

Finally, in the case of one crop at least, the present lay-out of the average village hampers economic development and prevents the cultivator from getting a fair price for his produce. There are

many tracts in this province where the grower would willingly sell his sugarcane to a factory at prices more favourable to the factory than obtainable in most cane-growing countries. But the small scattered holdings often make the transport problem insuperable although sufficient cane is already grown within a reasonable radius and more would be grown if a factory could be started. As a result the cane grown is not economically utilized and extension of cane cultivation is checked. In the writer's opinion the present tenancy system has a great deal to do with the comparative shyness of capital for enterprises of this nature.

It is realized that drastic legislation such as would be necessary to permit of the re-striping of holdings requires a strong public opinion to support it, and it is, therefore, suggested that the first step would be to acquire a few villages in different parts of the Province, carry out the necessary alteration, and re-let the new holdings to the original tenants as nearly as possible. An object lesson of this kind would soon convince the land-owning classes of the need for general measures and, pending legislation, some of them might be able to assist in carrying out partial schemes in their own property.

If any excuse is needed for bringing before a science congress a matter of purely economic importance it seems sufficient to say that the existing land tenure system of this Province imposes a limiting factor on the application of scientific method to agricultural improvement.

SCIENTIFIC METHODS IN AGRICULTURAL EXPERIMENTS.

BY

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Having had occasion recently to collate the results of a large number of field experiments conducted throughout India and having had some difficulty in drawing anything but vague general conclusions from them, it occurred to the writer that a plea for more scientific planning and execution of such experiments might not be out of place.

The Rothamsted experiments seem to have been taken perhaps too much as a model on which experiments in India should be planned rather than as supplying a basis of information to be utilized in devising experiments more particularly suited to Indian conditions.

The information provided by the Rothamsted experiments is of two kinds, relating, firstly, to the reaction of the Rothamsted soil, and of the crops grown there to different manurial applications, and, secondly, to the wider subject of field experiments generally.

Little need be said about the first of these aspects except as regards certain limitations to the direct application of the results to conditions other than those under which the experiments were tried.

These results have proved that the application of manures containing nitrogen and the elements found in plant ashes, in quantities of the order of magnitude in which these elements are removed in crops, has a marked influence direct or indirect on the production of crops.

They have shown also that by a continued application of a manure complete in all but one of the important ash elements, the productive capacity even of land that contains enormous reserves of that one element may, by the removal of the crops grown, be reduced, in a comparatively small number of years, to very much below normal. And they have shown how rapidly nitrogen may be accumulated by the growth of leguminous crops, provided that a moderate supply of these ash elements in a soluble condition is maintained.

But while a foundation for local investigations has thus been provided, in the principle of supplementing the weakest links in the chain of chemical elements on which fertility depends, by a supply of the deficient elements in a soluble form, no attempt has been made at Rothamsted even to illustrate by local example, the solution of what must always be a local economic problem—that of adapting agricultural practice so as economically to extract from the insoluble reserves in the soil, and maintain in a relatively available form, sufficient proportions of the principal elements required by crops.

The cropping of Rothamsted has been purposely exhaustive, and manures have been freely supplied from outside; no attempt has been made to make the most economical use of the reserves of plant food existing in the soil, the full utilization of which must always be, in greater or less degree, an object of agricultural practice.

The importance of this point is shown by the rapidity with which the available potash was exhausted at Rothamsted, on a plot which received a manure containing all the other essential elements of plant food; and this, although the soil when completely broken down by hydrofluoric acid, was found to contain over 2½ per cent. of potash. Mr. Taylor at Sabour has similarly found over 6 per cent. of potash (over 8 tons, per inch depth, per acre) in a soil from Ranchi—where, nevertheless, ashes form one of the chief manures.

Now India is a poor country, and cultivators cannot afford to import over the long distances into the interior, any great quantity of heavy manures; or to use, as manure, what might otherwise be

fed to cattle ; while on the other hand the relatively rapid weathering and denudation due to climatic extremes brings within reach of the surface every year, a relatively large quantity of fresh subsoil for exploitation by plants.

Looking through a large number of experiments it appears that while much labour has been spent on testing the commoner commercial manures, comparatively little has been spent on attempting to get the most out of the soil by particular study of its constitution and reaction to special treatment.

Moreover the special value of leguminous crops as subjects for experiment under the conditions just described, hardly seems to have been taken into account in designing experiments in India.

Another limitation, and possibly a very important one, to the utility of the particular results obtained at Rothamsted in designing experiments in India, is the fact that chlorine and sulphur are supplied in excess of the demands of crops at Rothamsted by rain ; owing perhaps to the comparative proximity of the sea, and to the large consumption of coal in England, and to the even distribution of the rainfall. The writer is not aware of any published figures relating to this point in India, but recent experience at Ranchi of the very remarkable effect of small quantities (10 to 40 lb. per acre) of sulphur, and of gypsum, on groundnuts, indicates that sulphur at any rate may sometimes be a limiting factor on high-lying well drained soils in Peninsular India which are subject to leaching by heavy rainfall. Under such circumstances the use of sulphur or of gypsum on control plots, in experiments with sulphate of ammonia or superphosphate, is essential if reliable information is to be obtained.

But the intention of this paper is not so much to point out particular differences between English and Indian manurial problems as to indicate the necessity for independent scientific surveys of local requirements before planning experiments, and to suggest that the use of the classical experiments at Rothamsted to investigators elsewhere, lies rather in the lessons that have been drawn from them as regards agricultural experimental methods in

general than in the direct application of the methods employed there.

From this point of view the value of the Rothamsted experiments lies in the number and reliability of the statistics obtained.

Examined in the light of statistical science these figures have demonstrated the very considerable magnitude of the 'experimental error' in field experiments conducted under the most favourable conditions; and, though it is now some years since this was pointed out, there is little evidence that the lesson has been taken to heart in laying out field experiments in India.

Hall in an article in the *Journal of the Board of Agriculture* in August 1909, quoted an instance of the yield of two unmanured grass plots one of which gave, on the average of 50 years results, 10 per cent. more than the other: but frequently gave over 30 per cent., and on one occasion 96 per cent. more; and on two occasions over 20 per cent. less.

In a subsequent paper in the *Journal of Agricultural Science*, October 1911, Hall and Mercer showed that the most careful methods of growing, harvesting and weighing plots of mangolds and wheat, under apparently uniform conditions, gave results that were subject to 'probable errors' sufficiently great to make comparisons of the results from a single pair of plots worthless for most purposes. They recommended that for practical purposes in any field experiment each unit of comparison should be given five plots of one-fortieth of an acre each, systematically distributed within the experimental area.

The authors attached considerable value to the scattering of plots throughout the area and showed that the shape of the plots had (as indeed would be expected) in itself, no appreciable effect in reducing the error. But in an appendix to their paper, one who signed himself 'Student' showed how considerably the error could be reduced by having the plots for comparison relatively long, narrow, and alongside one another. By dividing squares into pairs of plots for comparison, less than two-thirds of the area was required to obtain the same accuracy as by random comparison in the case of roots, and in the case of wheat, less than half.

These results, depending chiefly on avoidable or unavoidable physical differences between the plots, are, of course, not quantitatively applicable to conditions other than those under which they were obtained. But the principle is of greater importance in proportion as the effective control of the experimental area is less, and is probably therefore more important under the conditions obtaining on most experimental farms in India than it is at Rothamsted where minor variations in the soil are less accentuated by extremes of rainfall or drought, and where the work was laid out on land carefully selected for uniformity in the light of a previous known history.

Yet on how many farms in India are even the five plots recommended by Hall and Mercer considered necessary for each comparison; and, where only two, or at most three plots are used, what results worth having can be obtained in the limited number of years over which a consistent policy can usually be maintained?

Acting on the principles that have been emphasized, the writer made an attempt during the last monsoon to throw some light on the manurial problems of Chota Nagpur, where immediate results were required to supply an existing organization with material for propaganda.

The conditions were unfavourable, the farm at Ranchi was started in May 1915, the land being then uncultivated. The best land that could be selected was not by any means uniform, as it was intersected by low terraces and was being carted over by building contractors. Inequalities had to be ignored; carting was stopped; and six acres were divided by low ridges at right angles into 60 plots, each 40 links wide by 250 long.

Analysis of the soil having shown a marked deficiency of lime and phosphoric acid, and only a trace of sulphur, it was decided to devote the whole 60 plots to quantitative tests of the effect on groundnuts of lime, sulphur, and bonemeal—the latter being used only because raw mineral phosphates were unobtainable owing to freight difficulties. The general scheme was based on the division of the area into series of plots for testing the different manures,

alone and in combination; test and control plots being alternated throughout. In comparing the results, the weight of produce of each variant plot was compared with the sum of the weights from the control plots on either side of it.

The details of the results, which will be published in the Farm report, are of no particular interest, except in the case of sulphur, to which reference has already been made.

The effect of sulphur was quite phenomenal and would have needed no duplication of plots for its detection, even when only 10 lb. per acre (costing 12 annas) was applied. Slaked lime, in all quantities up to 5,600 lb. per acre, was also markedly beneficial.

But the general character of the results is best illustrated by those given by bonemeal. This manure gave a markedly increased yield in each of 5 plots to which it was applied without lime, but when applied in addition to 4,000 lb. of slaked lime per acre it gave a relatively much smaller increase in 6 out of 7 plots, and this increase had again to be discounted by a decrease of 20 per cent. on the seventh plot—a discrepancy clearly due to 'experimental error,' of the importance of which in this case it gives some idea. If the number of plots had been much smaller, either the significance of the results might have been overlooked, or the discrepancies might have led to their rejection as inconclusive. As it is, conclusions have been drawn which, while showing weak points in the original plan of the experiments, have both enabled immediate recommendations to be made to cultivators, and have provided a solid basis on which to plan a new set of experiments for next year.

THE IMPORTANCE OF SOIL VENTILATION ON THE ALLUVIUM.

BY

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I. INTRODUCTION.

THE dominant factor in the internal economy of the Indian Empire is the monsoon. The well-being of the people, the commerce of the country and the revenue collected by Government all depend on the amount and distribution of the summer rainfall. It is not surprising, therefore, to find that the attention of the agricultural investigator in India tends to be concentrated on questions relating to the supply of water to crops. At the same time, the other factors on which yield depends are apt to be obscured and crop-production comes to be regarded almost entirely as a question of water-supply. After ten years' observation of the crops grown on the Indo-Gangetic alluvium, during which a good deal of first-hand experience in agriculture has been obtained at Pusa in Bihar, at Lyallpur in the Punjab, and at Quetta in Baluchistan, the conclusion has been reached that a full supply of air in the soil is quite as important as a sufficiency of water. While air is a necessary raw material for the roots of plants wherever they may be grown, efficient soil ventilation is found in practice to be particularly difficult on alluvial soils like those met with over large areas of the plains of India. Alluvial soils, like those of the valleys of the Ganges and Indus, pack very readily and always run together on the surface after heavy rain forming a well-defined crust, well-known to any cultivator as the *papri*. Two chief factors are responsible for the ease with which

these soils form surface crusts after light showers and lose their porosity altogether after long continued rain. In the first place, the soil particles are small in size and exhibit no very great range in diameter and, in the second place, much of the rain comes in heavy continuous torrents quite unlike anything experienced in temperate regions.

Defective aeration of the soil, besides interfering with the respiration of the active cells of the root and of the soil bacteria, exercises a profound influence on the development of the root-system itself. Where the subsoil is wet and consolidated and gaseous interchange between the soil and the atmosphere has been checked, crops are found to develop superficial roots only and are then particularly liable to the harmful effects of drought. To withstand any shortage of moisture, to make the most of the brief growing season and to ripen the crop before the onset of the hot weather, the root-system of all *rabi* crops must be deep. In the *kharif*, long continued and heavy rain, by destroying the porosity of the soil and by thus interfering with the air supply to the roots and to the soil organisms, leads to a wilted, poverty-stricken condition of the crops and to a diminished yield. Such examples of damage to monsoon crops, caused by excessive rain interfering with aeration, were common in many parts of the United Provinces during the later phases of the 1915 monsoon.

II. Some Examples of Soil Ventilation.

Among the numerous instances observed of the effect of improved soil-ventilation on the growth of crops it will be sufficient to quote a few examples.

1. *The yellowing of peach trees.* As the summer progresses at Quetta, the foliage of many of the peach trees alters in colour and changes first to light-green and finally to yellow. Premature leaf-fall then takes place and, by the end of August, many of the branches are almost bare of leaves. In addition to the yellowing of the foliage, two other symptoms manifest themselves. The wood gives off large quantities of gum and the ripening fruit is deficient in flavour. Peach trees affected in this way die out in two or three

years, the process taking place in stages by the death of one or two large branches at a time. Investigation of the trouble showed that this unhealthy condition was not caused by want of available nitrogen in the soil and was not a real disease of the nature of the "peach yellows" of the United States. Buds taken from affected trees produced healthy plants and therefore the unhealthy condition was not transmitted in propagation. Yellowing was found to be reproduced at will, either by deep-planting or by over-irrigation. Any effective method of soil-aeration was found to transform affected trees into a healthy, vigorous condition in a single season. Yellowing and the premature death of the peach trees at Quetta was therefore found to be the result of defective aeration of the soil caused by excessive surface-flooding under arid conditions. The affected trees naturally carried a load of parasites such as scale insects and a certain number of fungi but with the resumption of healthy growth these pests gradually disappeared.

2. *Soil-aeration and green-manuring.* The provision of some cheap form of organic matter is one of the great needs of Indian agriculture at the present time. As is well known, the amount of manure available is small due to the fact that most of the cow-dung is burnt as fuel and almost all the *bhusa* is used for feeding cattle. As a rule, Indian soils are deficient in organic matter and the yield is limited by this factor. One theoretical method of making up the deficiency is by green-manuring but, in practice, difficulties arise. A considerable amount of attention has been paid to this subject in the Botanical Area at Pusa and the conditions necessary for the success of this operation have now been worked out. If a crop like *sanai* (*Crotalaria juncea*) is raised on the early monsoon rains and ploughed in during July, it is found that the texture of the soil is improved and, in a few cases on light land, the succeeding *rabi* crop benefits enormously by the addition of the organic matter left by the decay of the green crop. In the majority of Bihar soils, however, these results are not obtained and the *rabi* crops following green-manure are much worse than those raised on ordinary fallowed land. As a rule, green-manuring leads to a diminished *rabi* crop although the process results in the addition of a considerable

amount of organic matter to the soil. After some years' experiment, it was found that the factors on which success in green-manuring depends are connected with the air-supply in the soil. If the land is surface-drained and, if provision is made so that each field is protected from the run-off of other areas by a suitable arrangement of trenches, the effect of a green-manure crop is materially increased. If, in addition, the land is subsoiled to a depth of twelve inches before the *rabi* crops are sown, still better results are obtained. When broken tiles (*thikra*), at the rate of about 50 tons to the acre, are mixed with the upper six inches of soil, the results are exceedingly striking and a maximum crop can easily be obtained by green-manuring alone.

The simplest explanation of these results appears to be connected with the part played by air in the soil. The soil is usually regarded as a mass of small particles, arranged in various ways according to the degree of consolidation, with free spaces between these bodies known collectively as the pore-space. Surrounding the solid particles are films of water of various thicknesses while the rest of the pore-space is taken up by the soil-air. The proportion of the pore-space filled by water and air naturally varies with the general wetness or dryness of the soil. The closeness of packing of the solid particles varies greatly, after a crop is sown, as a result of consolidation by irrigation water or rain. In the water films round the particles, there is intense biological activity. Numerous bacteria are rapidly reproducing themselves while the root-hairs of the crop are competing with these soil organisms for water and inorganic food materials. All the protoplasm of these organisms is actively respiring and, in consequence, there is, in the water films round the particles, a keen struggle for oxygen and a great development of carbon dioxide. Under such circumstances, it is easy to understand how it is that analyses of the general soil-air often show a high proportion of carbon dioxide and a comparatively low percentage of oxygen. We must now consider what is likely to happen if this normal struggle for dissolved oxygen in the soil between the roots of the plant and the soil organisms is complicated by the sudden addition of a green crop like *sanai*. In the first place, the growth

of the green crop itself will naturally lead to a considerable pollution of the soil atmosphere by carbon dioxide. As soon as it is ploughed in, decay begins and an enormous quantity of oxygen is used up in the process which is by no means complete when the sowing time of a *rabi* crop comes round. The partly decayed organic matter adds a new competitor in the struggle for oxygen. It is easy to understand how the remains of the green crop might easily use up the oxygen in the pore-spaces and load the soil atmosphere with carbon dioxide to such an extent as to poison the air dissolved in the water films. Oxygen starvation and carbonic acid poisoning would affect the plant and growth would be checked. If we improve the aeration by drainage and by adding *thikra,* the decay of the green crop would be hastened and the air-supply of the soil during the succeeding *rabi* crop would be increased to such an extent that oxygen would no longer be a limiting factor.

The nodules of leguminous plants. The copious aeration of the soil in which leguminous crops are grown is perhaps more important than in any other class of cultivated plants. These crops require nitrogen for their nodules as well as oxygen for the respiration of the roots themselves. Once these facts are realized, it is easy to understand the distribution of leguminous crops in India and the agricultural processes in vogue in their cultivation.

The distribution of the gram crop closely follows the occurrence of well-aerated soils. It is only grown under irrigation where the soil is particularly porous or where there is a well-drained and well-aerated subsoil as occurs in many parts of the Bombay Presidency. If an attempt is made to grow this plant in stiff, heavy land, such as the low-lying loams of North Bihar, the result is disastrous. The plants only form roots near the surface and hardly any nodules are produced. The yield is scarcely more than the seed sown. Similar results are obtained under canal irrigation in the stiff loams in the Canal Colonies of the Punjab and other tracts of India. Heavy rains during the cold weather often destroy this crop simply by forming impervious surface-crusts and cutting off the supply of air to the nodules and roots.

In the growth of *rahar* (*Cajanus indicus*) in those tracts of India where the monsoon rainfall is heavy, the best results are obtained by digging the soil between the plants after the monsoon. Heavy rains consolidate the fine alluvium and the digging is necessary to restore aeration. In a similar manner, the Java indigo crop will only form seed in Bihar when the copious aeration of the roots is provided for. The slightest interference with the air-supply soon makes itself manifest by leaf-fall and by the shedding of flowers without setting seed.

III. The Maturation of Crops.

Besides its influence on the actual growth of crops, the provision of an abundant air-supply appears to be bound up with the ripening processes and with the development of quality.

In the case of the wheat crop, the best grown samples are always produced in tracts like the Meerut Division of the United Provinces or on the black soils of Central India, where the soils are naturally highly porous. In Bihar, Oudh, and in parts of the Punjab, where the natural porosity is not so great, the grain is always much thinner in appearance particularly in years when the rainfall is heavy during the ripening period. Unless the wheat roots get plenty of air during the process of maturation, the sample is always relatively poor.

Anyone who has studied the peach tree and has attempted to grow this fruit to perfection must have been impressed by the difference in quality of the same variety when the peach is grown on soils a little heavier than the normal. As is well-known, the peach thrives best on open soils and is particularly sensitive to any form of water-logging. Some years ago, the Botanical Section at Pusa achieved a local reputation on account of the excellence of the peaches grown there. The varieties were only country kinds but they were grown on high land containing a fair proportion of broken tiles (*thikra*). The soil was thus highly porous and the roots obtained abundance of air. The quality of the fruit was excellent compared with the produce of similar trees on land close by a little heavier in texture which contained no *thikra*.

In the growth of vegetables and flowers, some of the soils of Lucknow are famous. The best produce is raised under irrigation on the highly-manured sands near the banks of the Gumti. The soils in themselves are poor but, when properly manured and watered, their porosity is so great that surface-flooding causes little or no damage to its texture. The roots of the vegetables and flowers thus obtain abundant air and grow to perfection. The vegetables have excellent taste while the flowers easily form a quantity of good seed. Here again the development of quality seems to be closely associated with soil-aeration.

A similar result is seen in tobacco growing in Bihar. The best tobacco is grown on high, light lands which have been manured with indigo *seeth.* The *mahajans* pay more for such produce and several of the indigo factories have a reputation for their tobacco. *Seeth* is undoubtedly a most efficient aerating agent and all the experience obtained at Pusa in the growth of the tobacco crop points to the supreme importance of soil-aeration in the ripening of this crop. Once more, quality appears to be closely bound up with the ventilation of the soil which again appears to be of supreme importance in the process of maturation.

THE DYEING VALUES OF SOME INDIGENOUS DYE-STUFFS.*

BY

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I.

Natural dye-stuffs are perhaps not as bad as they have come to be regarded since their displacement by coal-tar colours. India boasted of a comparatively well developed art of dyeing in the earliest stages of the historic period. The ancient Indian dyer could dye some very good colours with the help of colouring matters derived from the natural and mineral kingdoms. Some of these colours were fast in every sense of the word and answered all the requirements of the people for whom they were intended. This points to the possibility of valuable colouring matters lying unknown or forgotten in the forests and jungles of this country.

A large number of woods containing red and yellow colouring matters are still used even in Europe but all these are obtained from America. There are undoubtedly similar woods in this country but so far no systematic investigation seems to have been made.

If America can find a market for so many dye-stuff extracts made from woods and other natural products, surely we with our vast, varied, and plentiful natural resources ought to have little

* Of the two papers printed here only the second was contributed to the Indian Science Congress. The first was published by the Board of Industries, United Provinces, before the Congress was held. It has, however, been reprinted here as the second paper is in continuation of it.

difficulty in finding out and placing on the market similar products.

This question is of special importance at the present moment. The stoppage of the supply of German dye-stuffs has caused grave inconvenience in all colour-using industries. If Indian dye-stuffs had not been entirely discarded the distress would not have been so acute. At least some part of the world's requirements would have been met by the dye-stuffs indigenous to this country.

Colouring matters are widely disseminated in the vegetable kingdom. Some one has said that any one who wishes to spin, dye and weave his own raw material at his own fireside need not go far afield for his colouring matters.

Such is indeed the case in a great many places where cottage industries still flourish. In Donegal, famous for its homespun tweeds, the colouring matters used are still mostly derived from lichens and roots. The colouring matters of Donegal possess great fastness and beauty and their methods of application are alike novel and interesting.

I visited Donegal in December 1909 and submitted to the Secretary of State for India a report on the subject of the cottage industries of the congested districts of Ireland. I have alluded in this report to the processes of dyeing used in Donegal.

The following investigation into the dyeing values of certain natural colouring matters still used by native dyers was undertaken under the orders of the Director of Industries, United Provinces.

The colouring matters were tried on wool and cotton by some of the more important methods of modern dyeing.

The methods employed were as follows :—

A. On Wool.

(*a*) Dyed in an infusion of the colouring matter without the addition of any chemical or assistant to the dye-bath.

(*b*) Dyed in an infusion of the colouring matter with the addition of 4 per cent. acetic acid.

(*c*) Dyed as in (*b*) and after-treated in the same bath with 2 per cent. potassium bichromate.

(*d*) Dyed in an infusion of the colouring matter on wool which had been previously mordanted with bichrome and oxalic acid.

(*e*) Dyed in an infusion of the colouring matter on wool which had been previously mordanted with aluminium sulphate and tartar.

B. ON COTTON.

The cotton was steeped overnight in a decoction of myrabolans, next morning it was taken out, squeezed and without washing worked in fresh baths containing the following :—

(*a*) Tartar emetic.

(*b*) Stannous chloride.

(*c*) Alum.

(*d*) Ferrous sulphate.

Generally speaking all the dye-stuffs described hereafter gave the most brilliant results on stannous chloride ; tartar emetic and alum coming after that. Ferrous sulphate, as might be expected, dyed grey to black shades.

The inquiry has so far been prosecuted in regard to the following colouring matters :—

(1) HARSINGHAR. (*Nyctanthes Arbor-tristis*).

The flowers of this tree contain a beautiful yellow colouring matter. The tree is found in abundance in the United Provinces and when in bloom yields large numbers of flowers which generally open at night and fall to the ground in the morning. The flowers are collected, dried, and afterwards sold to dyers.

The colouring matter contained in the flowers is soluble in water, also in alcohol. An extract can therefore be easily made.

Harsinghar gives brilliant yellow shades with all mordants on wool. On wool mordanted with bichrome and oxalic acid previous to dyeing a beautiful brown is obtained. The dyeings on wool possess good fastness to milling with soap and soda.

(2) TUN. (*Cedrela Toona*).

This tree is said to occur largely in the sub-Himalayan forests. The colouring matter is contained in the flowers which are dried and sold. The principal constituent of the flowers is a yellow dye.

Tun dyes the best shade on wool in conjunction with mordant A(*d*). The dyeings on wool are, however, not very fast to milling with soap and soda.

(3) Tesu or Dhak. (*Butea frondosa*).

This tree is found in abundance all over the United Provinces. The dye extracted from the flowers is still largely used by villagers for sprinkling on their persons as a mark of festivity at Holi festival, about which time the tree is in full bloom. The dried flowers are, however, available throughout the year. The flowers contain a yellow colouring matter.

Tesu dyes on wool shades varying from brown to dull crimson according to the mordant used.

The dyeings are fairly fast to milling.

(4) Haldi or Turmeric. (*Curcuma longa*).

The plant which yields *haldi* is grown all over the United Provinces. *Haldi* is a dried rhizome or tuber and is a well-known constituent of curry powder. It is largely used as a spice and can be had in any quantity in the bazar. It contains a brilliant yellow colouring matter which however possesses the serious drawback of being changed into red by soap or by alkalis.

The colouring principle of *haldi* is called *curcumin;* it is sparingly soluble in cold water, more freely in hot water, and completely in alcohol. The use of turmeric paper in analytical chemistry is well known. Paper saturated with a solution of turmeric is changed to a reddish brown colour by alkalis; while its reaction with boric acid is still more characteristic. Turmeric paper on being moistened with boric acid and dried becomes brownish red which colour is changed to blue or green by caustic soda.

On wool the best shade is obtained on chrome mordant A(*d*). The fastness of the dyeings on wool is fair.

(5) Arusa. (*Adhatoda vasica*).

The leaves of this plant yield a yellow colour. *Arusa* is an ever-green plant and is found in the United Provinces. The

colouring matter in *arusa* is soluble in water and also in alcohol. The leaves contain a large amount of chlorophyl which is extracted along with the yellow colouring matter. The chlorophyl considerably dulls the dyeings obtained with *arusa*. The yellow dye was separated by adding water to an alcoholic extract of the leaves. The chlorophyl was thereby thrown out of solution and the yellow colouring principle was obtained in the filtrate. This gave much better results in dyeing. On wool the best shade is obtained on chrome mordant A(*d*). The fastness of the dyeings on wool is fair.

(6) NASPAL OR POMEGRANATE RIND. (*Punica granatum*).

This plant is well known for its fruit. The rind of the fruit contains a tanning substance and also a yellow colouring matter, the latter in much smaller quantity than the former.

Pomegranate rind dyes very good shades varying from yellow to full brown on wool. All these possess very good fastness to milling.

(7) JANGLI NIL OR WILD INDIGO. (*Tephrosia purpurea*).

This is a small woody annual occurring in abundance in the United Provinces. It does not contain any substance yielding indigo and its name " Jangli Nil " is probably due to its similarity to the indigo plant.

Clarke and Banerjee have examined the constituents of the leaves of this plant. They found in it a colouring principle allied to quercetin or quercitrin (vide *Trans. Chem. Soc.* 1910, V. 97). Owing to the difficulty of separating the yellow principle from the chlorophyl, efforts to obtain a pure yellow from *Tephrosia* have only been partly successful. The colouring matter is, however, of great value, as it yields dyeings which are comparatively fast to light, washing, and milling. The yellow principle was separated by extracting the dry leaves with alcohol, diluting the extract with water, and washing away the chlorophyl with petrol. The purified colouring matter gave excellent shades of yellow in conjunction with various mordants. On account of the abundance of the plant it may be worth while devising a suitable process for extracting

the yellow colouring principle. It would no doubt be very welcome wherever fustic and quercitron bark are still in use. A decoction of the leaves of *Tephrosia* dyes wool mostly dull brown shades in conjunction with the various mordants, the most brilliant shade being that on tin mordant. The dyeings, however, possess very good fastness to milling.

(8) SAFFLOWER OR KUSUM. (*Carthamus tinctorius*).

The dried flowers of safflower plant contain a colouring matter which before the introduction of coal-tar colours was highly prized all over the world. It produces on cotton beautiful shades of red varying from a full crimson to the most delicate pink. Safflower is rather an interesting material. It contains two distinct colouring matters, viz. (1) a yellow soluble in water which is by far the larger constituent, and (2) a red which only occurs in small quantities but is, nevertheless, the more valuable of the two. The separation of the two colouring matters is thus effected. The florets are macerated with water which extracts the yellow colouring matter. When the maceration is complete and yellow colouring matter is no longer extracted, the florets are mixed with a dilute solution of carbonate of soda (*sajji matti*) which extracts the pink colouring matter. The cotton is worked in this solution in the cold for a short time. The bath is then acidulated with tartaric acid and the cotton worked in it for a short while whereby the pink colour makes its appearance. Native dyers use lemon juice for acidulating. The action is similar to that of tartaric acid. Silk may be dyed similarly but safflower is not suited to dyeing wool.

Although the yellow colouring matter in safflower is generally regarded as useless, Hubner has shown that certain mummy cloths which he examined had been dyed with safflower yellow (vide *Journal of the Manchester School of Technology*, Vol. 3, page 359). He found that these cloths contained appreciable amounts of magnesium sulphate, and his experiments proved that an addition of magnesium sulphate helped cotton previously mordanted with iron to take up the yellow dye pretty well and the shades obtained were similar to those of the mummy cloths. The Egyptians

were therefore acquainted with the right way of using safflower yellow.

Strange as it may appear, safflower yellow does not dye cotton in conjunction with aluminium and tin mordants.

Wool, however, possesses affinity for the yellow colour and may be dyed direct.

(9) Majith. (*Rubia cordifolia*).

The root and twigs of this plant contain a dye-stuff identical with madder. *Majith* was largely used in this country before the advent of synthetic alizarine. Its cultivation has now, it seems, entirely gone out. It is at present greatly in demand all over India, but enquiries made so far have shown that it cannot be had in quantities large enough to meet the demand for it. It is undoubtedly one of the most valuable indigenous dye-stuffs. With its help red, maroon, and bordeaux shades of excellent fastness to light can be dyed on all fibres. It is the basis of a great many colours required by the calico-printers. The Farrukhabad calico-printers were at one time large users of this dye-stuff and would be glad to go back to it if supplies were forthcoming. *Majith*, as might be expected, dyes very fast shades on both wool and cotton. The best results on cotton are obtained by using the Turkey Red process.

(10) Cutch or Katha. (*Acacia catechu*).

The catechu tree is found in several parts of India. An extract made by boiling the wood in water is still largely used in dyeing. Catechu is exported to Europe for use in dyeing and tanning. Catechu may be applied to all fibres, though it is most largely used for dyeing cotton. The usual method of dyeing cotton consists in boiling the goods with an extract of catechu with the addition of copper sulphate, the weight of the copper salt being 10 per cent. of the weight of the colouring matter. The goods are squeezed, allowed to stand for a short time, and then boiled in a fresh hot bath containing 2 per cent. bichromate of potash, washed and dried. Catechu brown is one of the fastest colours known.

(11) PATANG OR SAPPAN WOOD.—(*Cæsalpinia sappan*).

This tree is said to grow abundantly in Cuttack and in Central India. It is a variety of the so-called Brazil wood which was once upon a time very largely used in dyeing in Europe. The colouring principle, *brazilein*, exists in a colourless condition in the freshly cut wood and is by oxidation converted into the true colouring matter *brazilein*. The wood is similar in its composition to logwood. The oxidation of the colouring matter is carried out by a process of "ageing" in exactly the same way as logwood.

Patang is a valuable colour-yielding material. It can be used for producing brilliant shades of red, crimson, and purple and is very suitable for calico-printing.

(12) LAC DYE.

This substance is of animal origin. It is the product of a small insect called *Coccus lacca* which lives on the twigs of certain trees such as *peepul* and *ber*. The incrustation produced by these insects on the twigs of the trees consists of (1) resinous matter, (2) colouring matter. The colouring matter is dissolved out by means of water or a weak alkali, the resin being left behind. The latter on melting and straining through canvas cloth constitutes *shellac*. The colouring matter is precipitated from its solution by means of alum and is afterwards pressed into cakes and sent out either for export or for sale locally.

Lac dye is manufactured largely in these provinces, though like other natural products it has lost much of its former importance Lac dye is dyed on wool, chiefly on tin mordant. It yields beautiful scarlet and crimson shades.

(13) INDIGO.

A description of this is perhaps unnecessary here. Its use and importance are too well known to be drawn attention to in this paper.

CONCLUSION.

In the scope of this report it has been only possible to allude briefly to the dyeing values and properties of the various colouring

matters examined. Exhaustive trials have already been made with all the above dye-stuffs in conjunction with various mordants on both wool and cotton. The dyeings obtained in each case have been tested for fastness to light, washing, and milling. All these samples are being shown at the Exhibition of German and Austrian Goods now open at the Upper India Chamber of Commerce, Cawnpore.

These samples have already attracted the attention of users of dye-stuffs who have visited the exhibition, and enquiries respecting them have been received from one or two places.

Surprising as it may appear at first sight, India's natural resources are capable of supplying dye-stuffs required for producing any colour.

The thirteen dye-stuffs described above will enable a clever dyer to produce almost any colour.

We have in the list dye-stuffs yielding yellows, olives, browns, khakis, slates, greys, blacks, reds, scarlets, pinks, and blues. Suitable combinations of these colours will give us almost any shade.

The fastness of many of these dye-stuffs is not so bad as one is often led to believe.

It must, however, be admitted that most of these dye-stuffs are not available to-day in large quantities and the prices are consequently prohibitive.

Haldi, *cutch*, safflower, lac dye, and indigo are commercial products and may be had in fairly large quantities. *Tun*, *tesu*, *arusa*, and *Tephrosia* occur wild and arrangements may easily be made for collecting them. *Harsinghar* and *naspal* are not exactly wild products and so their collection will necessitate special arrangements being made.

Majith and sappanwood are perhaps the most difficult to get at and so far as we have been able to gather their cultivation has practically gone out, but an enquiry into the matter is still proceeding.

A systematic study of the properties and methods of application of these dye-stuffs would no doubt bring to light many valuable facts which would make the dye-stuffs more popular with the dyer.

There is every likelihood of a great many more colouring matters being found in the forests of India but this would be a matter for the Forest Department to deal with.

II

The examination of indigenous dye materials has been continued in the Technical Laboratory at Cawnpore. A communication on this subject has already been made to Government. Since then some additional dye materials have been examined and the following is a brief account of their properties and methods of application in dyeing.

(1) Kachnar—(*Bauhinia racemosa*).

This is a shrub very common in these provinces. The bark yields a red dye which is largely associated with tannin. The dye is not very bright but nevertheless it may be employed for dyeing dull reds on cotton. It may be dyed on cotton without the help of any mordant. Cotton seems to have an affinity for it. Faster results are obtained on alumina or tin mordant. *Kachnar* bark is said to be used in Burma for obtaining a dull black colour on cotton. For this purpose the cotton is dyed direct in an infusion of the bark and is then worked in mud whereby the dull red colour is changed into a black (*vide* note by the Conservator of Forests, Eastern Circle, Burma, 1896). The bark can be had in any quantity, and may be of service to tent manufacturers who require a dull red colour for the inside of tents.

(2) Peepul—(*Ficus religiosa*).

The roots of this well-known plant were examined and found to contain a red dye which gives a good pink on cotton mordanted with alumina. The shade so obtained is fairly fast.

(3) Red Sanderswood—(*Pterocarpus santalinus*).

This is a small tree occurring in Southern India. The wood yields a valuable red dye. It was largely used in dyeing before the advent of synthetic colours. The dye principle is called santalin. It was prepared in the laboratory in an impure state from an ethereal

infusion of the wood. The crystals deposited from the ethereal solution were further purified by washing them well with water, redissolving in alcohol, and precipitating with lead acetate. The precipitate was well washed with boiling alcohol and decomposed with sulphuric acid in the presence of alcohol, on removing the lead sulphate and concentrating the solution pure crystals of santalin were obtained. They melted at 103-105°C. (un-corr.)

Sanderswood dyes wool without any mordant. Very good shades of satisfactory fastness are obtained on cotton on tin and alumina mordants. The dye does not dissolve in water though it is freely soluble in alcohol, ether, and acetic acid.

(4) Roli or Kamela Powder—(*Mallotus philippinensis*).

This dye is obtained from a small tree found along the foot of the Himalayas and in Southern India. The fruits have red glands on the surface of the capsule and the powder is obtained by crushing or breaking up these glands. Kamela used to be largely employed for dyeing silk. It gives a beautiful yellow on silk mordanted with alumina. The shade obtained compares favourably with that dyed with chrysophenine. The dyeing must be done in an alkaline bath.

(5) Akhrot—(*Juglans regia*).

The bark yields a valuable brown dye. It is of special importance for wool at the present moment because it yields on this fibre a fast shade which may easily be modified to a khaki. A great many dye trials were made and as a result of these the following conclusions were arrived at :—

(*a*) The deepest shade is obtained by dyeing with an addition of 3 per cent. acetic acid to the dye-bath. The fastness to light is, however, poor in this case.

(*b*) Fairly full shades were obtained on chrome-oxalic acid mordant or by the after chroming process. Both these give dyeings of excellent fastness to light and milling. The poorest results both as regards

depth of shade and fastness to light and milling were obtained when the dyeing was carried out with an addition of 15 per cent. Glauber's salt to the dye-bath.

(6) KATHAL. (*Artocarpus integrifolia*).

The wood yields a yellow dye which may be dyed on cotton on alumina mordant. The shades obtained are good and fast.

(7) BARBERRY. (*Raswat*).

The bark, roots, and stem of this plant are rich in a very good yellow dye. This plant is plentiful in the Kumaun Hills. The aqueous infusion of the bark and stem is used as a medicine for ophthalmia and is highly prized as such. The dye principle of barberry is berberine which is an alkaloid containing nitrogen. Berberine was prepared in a state of purity from barberry by adding alcohol to the aqueous extract whereby all foreign matter was precipitated. On concentrating the filtrate crystals of barberine were obtained which were purified by recrystallisation from water.

Raswat is used chiefly as a dye for silk. It was dyed on cotton mordanted with alumina but dull shades were obtained. This was perhaps due to the presence of chlorophyl in the preparation which came from Naini Tal.

(8) *Rhus cotinus.*

The wood of this plant yields a dye similar to young Fustic. On cotton mordanted with alumina an orange yellow colour was obtained; with tin an orange red was obtained. The dyeings are, however, not fast to alkalis and soap.

THE AQUATIC WEEDS OF THE GODAVARI AND PRAVARA CANALS OF THE BOMBAY PRESIDENCY—A PROBLEM IN APPLIED ECOLOGY.

BY

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In 1915 the author was invited to examine and report on the weed growth in the Godavari and Pravara Canals of the Bombay Presidency, since this growth had in some places become so great as seriously to impede the flow of the water. The Godavari canals were accordingly examined from their pick-up weir at Madmeshwar lake to mile 31 on the Left Bank Canal and mile 49 on the Right Bank Canal. Similarly the Pravara Right Bank Canal was examined from its head-works for 18 miles. The Pravara Left Bank Canal, being still under construction, was not examined.

The weeds discovered were the following :—

(1) *Potamogeton perfoliatus*, Linn.
(2) *Potamogeton pectinatus*, Linn.
(3) *Vallisneria spiralis*, Linn.
(4) *Hydrilla verticillata*, Casp.
(5) *Naias* (?) species.
(6) An alga, resembling *Oedogonium.*

With the exception of the alga, the weeds mentioned are plants rooted in the soil, with their shoots rising into the water to various heights. *Potamogeton perfoliatus* (Plate VI), is the most serious pest, and the impeding of the flow in the canals is due to it. This plant has a creeping rhizome, two to four inches below ground, from the nodes of which slender adventitious roots penetrate deeper into the

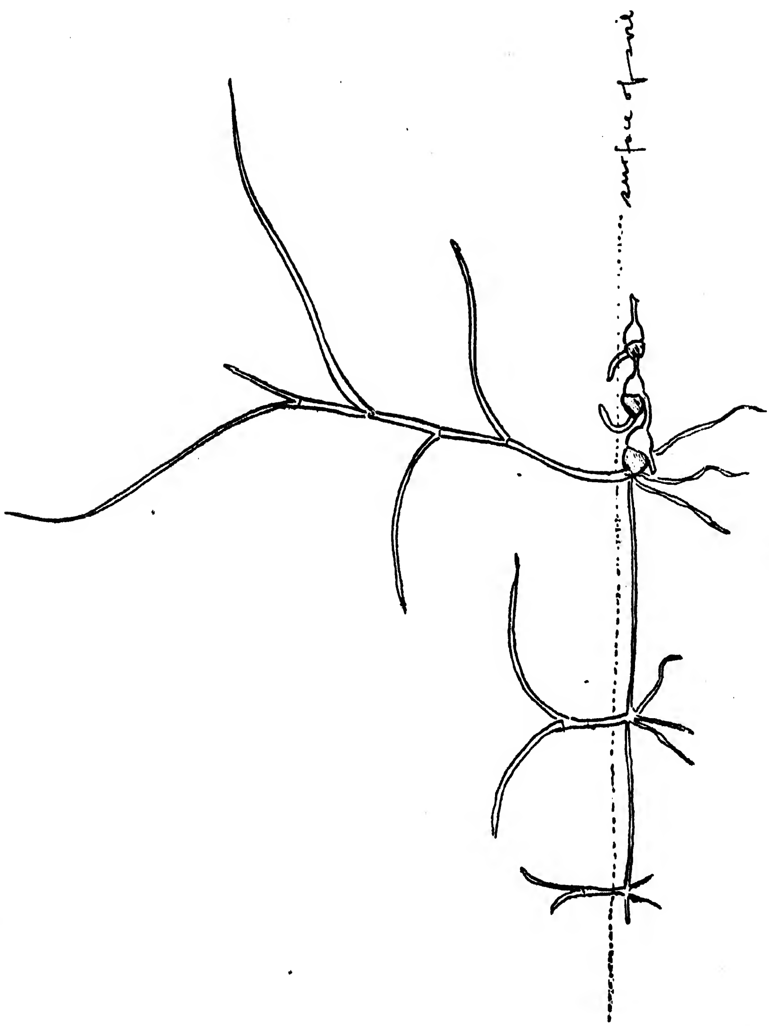


Fig. 2.

Plant of *Potamogeton pectinatus* 17 days after germination of resting tuber; two ungerminated tubers attached. Natural size.

(Semi-diagrammatic.)

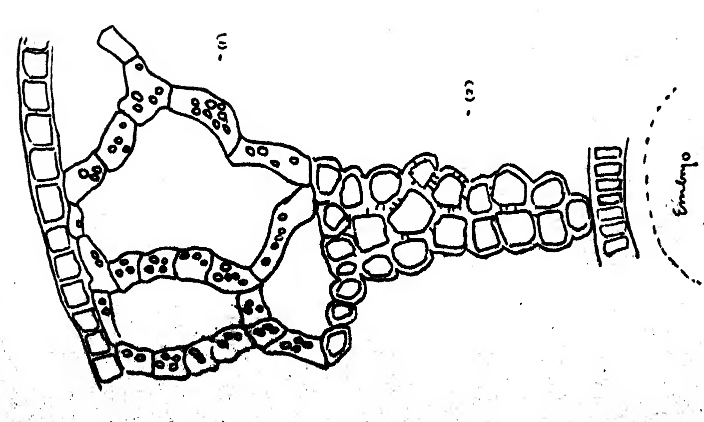
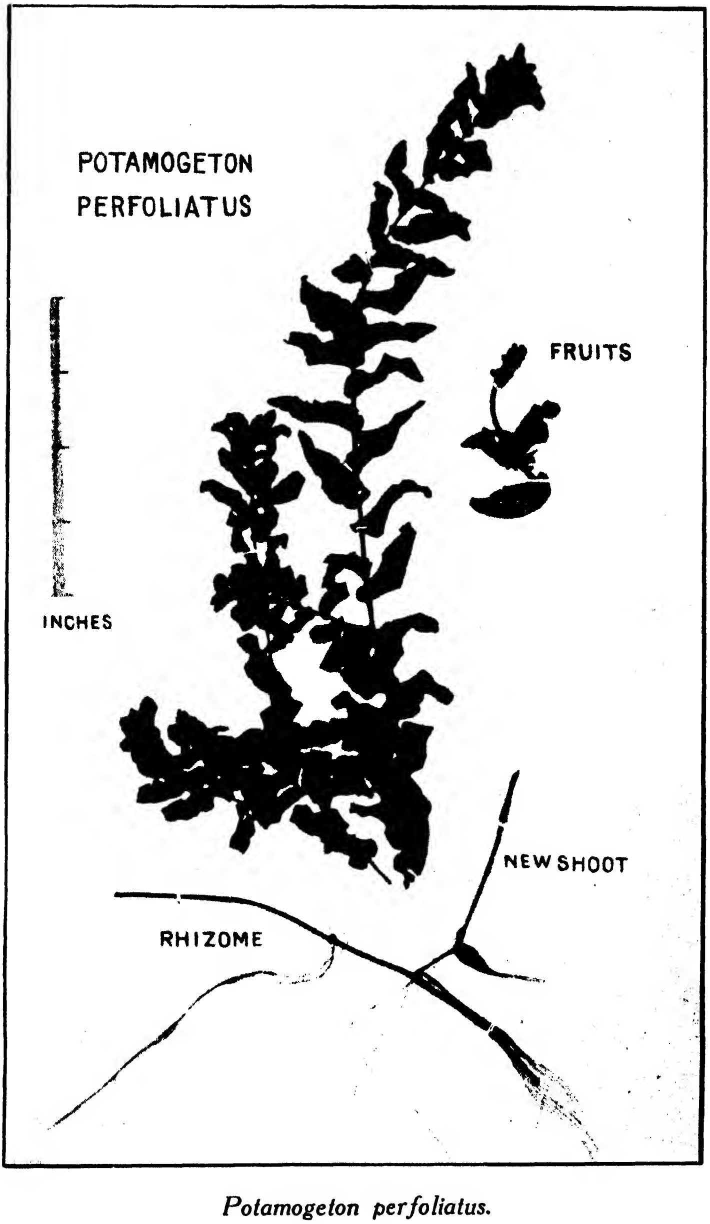


Fig. 1.

Transverse Section of Fruit coat of *Potamogeton perfoliatus*, showing
(1) starch containing floating tissue, and
(2) protective sclerenchymatous sheath.

× 124.

Semi-diagrammatic.)



Potamogeton perfoliatus.

soil. The growth of this rhizome appears to be monopodial. The stems arising from its nodes may be of great length. One taken at random from Madmeshwar lake measured 12½ feet from root to tip, the branches and leaves being confined to the top 2 feet. In the 49th mile of the Godavari Right Bank Canal, in water 10 feet deep, two stems taken at random measured 12 and 10 feet respectively with branches and leaves on the terminal 1½ feet. It is unnecessary to give a detailed botanical description of the plant, but points of ecological interest must be considered. Among these, the reproduction of the plant is of the first importance. As already mentioned, the creeping stem forces its way through the soil, sending up new above-ground stems. Reproduction by fruits appears to take place freely. In the Madmeshwar lake many plants of *P. perfoliatus* were in flower or fruit. The small compact spikes stand about one inch above the water. The method[1] of pollination is by wind, and judging from the copious formation of fruits, conditions are favourable. Some of the fruits fall off from the spike and float for a time, and it may be that the whole spike also becomes detached, but this has not yet been observed by the writer. The fruits are 1 mm. × 2 mm. × 2 mm., ovate and pointed in shape, and very thick coated. Fig. 1 shows a cross section of such a fruit with floating and protective tissues. The length of time that these fruits float and the factors affecting it have not yet been determined. This point is important, especially in the present case, where the regulators of the pick-up weir are so arranged as to draw off the surface water only.

It is probable that the Godavari canals have been infected from the Madmeshwar lake by the drifting down of these floating fruits. Leaving this point for the moment let us see if there is any discoverable reason for the extraordinary prevalence of *Potamogeton perfoliatus* in the said lake. The weir which is the cause of the formation of the lake was completed a few years ago. After its completion, a considerable area of previously dry land was submerged and one village had to be vacated. In the first year after the

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[1] Knuth, *Handbook of Flower Pollination* (Answorth Davies), vol. III, p. 507.

completion of the weir no weeds were observed in the lake. The exact date of their appearance is doubtful. It is possible that fruits of *Potamogeton perfoliatus* from plants in higher pools of the Godavari drifted down into the lake. The newly submerged land would be, as far as aquatic plants were concerned, *a denuded area*, and invasion would be easy. It is interesting to note that the portions of the lake occupied by weeds correspond roughly to the recently submerged areas, while the beds of the Godavari and Kadwa rivers, running through the lake, are clear of weeds. At the same time there are clear patches of water close to weedy areas which cannot be thus easily accounted for. It may be that at such points the substratum is not suitable for the growth of the rhizome.

The freedom of the river beds from weeds is probably due to the greater depth, and possibly to the greater opacity of the water. The influence of the Godavari is felt more in the Right Bank Canal and, if the water reaching that canal is coming unusually directly from the river channel, then the water is more muddy and at the same time more free of floating fruits of *P. perfoliatus*. Such a direct flow appears to have occurred in 1915, weed growth in the Right Bank Canal having been considerably retarded during September and October, although other conditions appeared normal.

The weed grows in water from 1 foot to 20 feet deep. This latter figure is not the maximum depth at which it can grow, but is merely a deep sounding taken casually in a weed area in the Madmeshwar lake. Scott Elliot[1] reports *Potamogeton* at 26 feet in Bruyant, France.

Variations of turbidity or velocity of water seem to have little effect on the distribution of the weed. The leaves occurring on the last 2 feet of the stem are always just below the surface and hence get plenty of light even if the water be muddy. The weed was found in water of all velocities from zero to 4 feet per second and thrives equally well in them all.

It is a curious circumstance that the weed occurred also here and there in borrow-pits beside the canal but having no direct

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[1] Scott Elliot, *Modern Botany* (1910), p. 132.

connection therewith. There are three possible explanations of the infection of these borrow pits. The fruits may have been carried (1) on the feet and feathers or in the stomachs of aquatic birds, or (2) in mud on the feet of cattle, or (3) they may have come from bunches of the weed piled on the banks at the time of cleaning of the canals. The fruits may then have been washed or blown down into the pits.

Complete closure of the canal for a prolonged period would doubtless kill the weed, but there is so much land under perennial irrigation from the canal that a prolonged closure is impossible. A closure which is sufficient to kill the exposed stems does not affect the under-ground rhizomes, which begin growth when water is once again let down the canal.

The vegetative growth of the weed is considerable from November to February and is at its maximum during December and January, just after its fruiting period in November. During the hot weather the vegetative growth diminishes, and is more or less dormant during the rains. In this respect, this aquatic weed forms a remarkable contrast to most of the land vegetation of its neighbourhood.

It is possible that the fall in temperature during the rains is the factor that checks weed growth. The factor of extra silt and consequently greater opacity of the water must also be taken into account. Only experimental evidence, however, can determine which of these factors is the more important.

Any methods for controlling this weed must, as far as these observations go, aim at (1) the prevention of fruit formation in the Madmeshwar lake so as to avoid further infection of the canals; (2) the repeated cutting or dredging by suitable apparatus of the weed in the lake to prevent its further spread therein; (3) the extirpation of the rhizomes of the plants now established in the canal. Means to attain these three ends are being considered.

Of the other weeds, *Hydrilla*, *Naias* (?) and *Vallisneria* were found in Madmeshwar lake completely submerged and out of sight in 4 feet of water. None of them were in fruit. They occurred at various points in the canals but were not serious pests.

Potamogeton pectinatus was found in flower at three points in the canal. It was found also in the lake. On account of its linear leaves, it does not hold up the water in the same way as *Potamogeton perfoliatus*. *Potamogeton pectinatus* has peculiar vegetative reproductive bodies not mentioned by Hooker, Cooke, or Woodrow, but briefly referred to by Continental writers.[1] These bodies are small rhizomes consisting of closely packed tubers; each tuber having on one side a shoot ready to start into growth, and on the other a slender internode connecting it with the next tuber. Small chains of these tubers were found both floating in the water and buried in the soil of the canal. The author was absolutely ignorant of their relationships until he grew one experimentally and got from it an unmistakable plant of *Potamogeton pectinatus*. Fig. 2 on p. 66 shows the plant produced. The germinating of such resting-bodies at this season tallies with the cycle of growth already noticed in which the monsoon is the resting season for such aquatic plants.

In the Pravara Right Bank Canal the weeds were much fewer, and the head-works, which is comparatively small, showed only one specimen of *Potamogeton pectinatus* and no *Potamogeton perfoliatus*. The latter is, however, found in the canal and the infecting fruits doubtless come from higher up the river.

The whole question of the control of the weeds of these canals constitutes a most interesting problem in applied ecology.

ADDENDUM.

Since the above paper was written for the Indian Science Congress, further collection of weeds from the Madmeshwar lake, and observation of specimens grown in tubs have brought to light the fact that the floating stems have the power of producing rooted branches adventitiously. It is likely that these branches later on fall off or are detached by the decay of the parent branch. This discovery makes the task of eradication of the weeds even more

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[1] Engler and Prantl, Natürlichen Pflanzenfamilien II Teil, I Abteilung p. 195 Handwörterbuch der naturwissenschaften, X Band, 519.

difficult since it will be necessary not only to prevent fruit formation, but to check the drifting down of these rooted and detached branches.

Fruits sown under water in November 1915, germinated in March 1916.

The artificial conditions in the tubs induced flowering after four months.

It appears also that there are probably three varieties of *Potamogeton perfoliatus* in the lake. Specimens of these are now being grown to determine if they are genetically distinct.

IRRITABILITY OF THE BLADDERS IN UTRICULARIA.

BY

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A SPECIES of *Utricularia* very near *flexuosa* is a free floating insectivorous plant (found in a tank in Madras). The leaves are finely dissected. The bladders that entrap insects hang by short stalks from the axes of the leaves (Plate VII, fig. 1). They are oval in shape and are broader in one direction than the other. The mouth of the bladder is horse-shoe shaped, with the bend of the horse-shoe posterior and the base anterior. The mouth is surrounded by a ridge which is produced at the two ends of the base of the horse-shoe into two stout projections from which branched hairs start. These hairs are referred to by Darwin as the antennæ. Except along the base of the horse-shoe the ridge is fringed with long pointed hairs (Plate VII, fig. 2, and Plate VIII, fig. 1).

The valve or trap-door of the bladder is attached to the inner and lower margin of the ridge all along the base of the horse-shoe and to a very short extent along the sides. In the living condition the valve is not flat as is commonly supposed but is transversely convex and dome-shaped when looked from above. The apex of the dome lies very near the bend of the horse-shoe so that the curve of the arch rises very gradually from the base up to very near the bend of the horse-shoe and then has a sharp fall (Plate VIII, fig. 2). From the apex of the dome start six or eight long pointed hairs arranged in two sets with a short space between. The hairs stretch towards the base projecting slightly upward and are nearly as long as the

PLATE VII.

Fig. 1. *Utricularia* Sp., very near *U. flexuosa.*

Fig. 2. Single bladder enlarged. Horse-shoe shaped ridge or "collar" round the mouth, produced into two branched hairs called the "antennæ" and surrounded with simple hairs. The shaded portion on the valve near the base of the horse-shoe shows the position of a large number of secretory hairs. The six irritable hairs on the valve are seen pointing towards the antennæ.

Fig. 1.

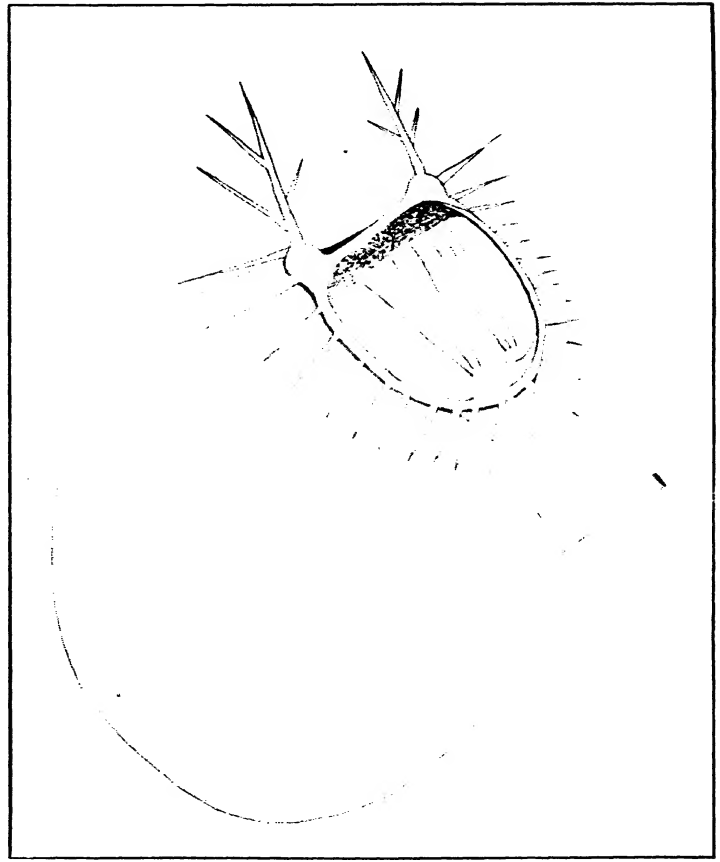


Fig. 2.

PLATE VIII.

Fig. 1. Surface view of the mouth with the valve. For explanation refer plate VII, fig. 2. The hairs surrounding the collar are omitted.

Fig. 2. Median longitudinal section, showing the mouth closed up by the valve. The free margin of the valve presses against the collar from below. The irritable hair is shown on the valve.

PLATE VIII.

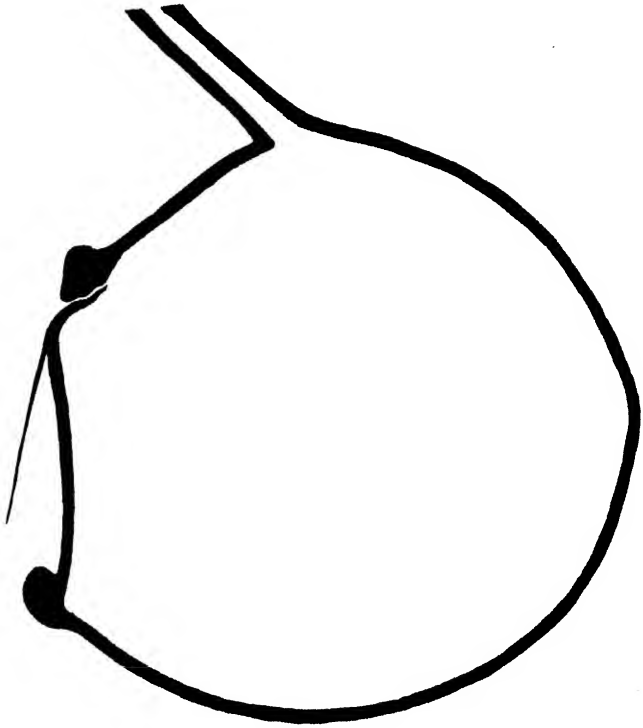


Fig. 2.

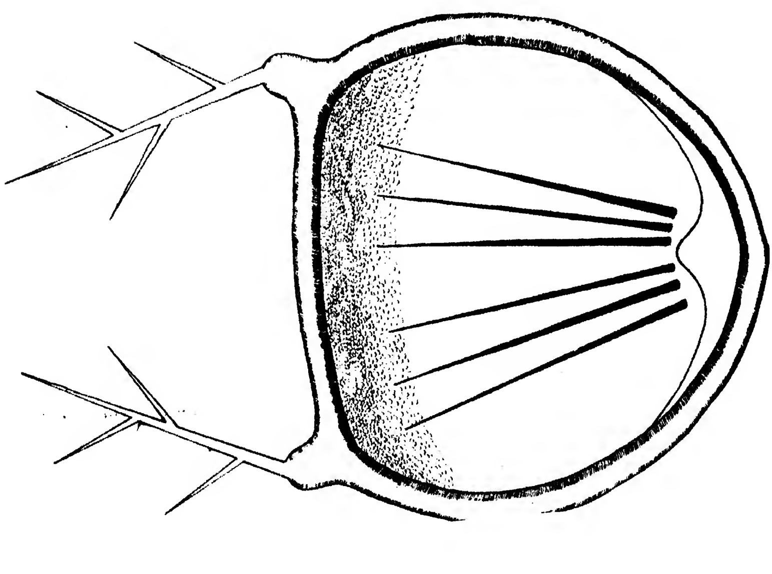


Fig. 1.

valve. The portion of the upper surface of the valve nearest the base of the mouth is densely clothed with club-shaped hairs which are glandular and secretory. The valve has a thin margin which goes below the ridge of the mouth all round and is tightly pressed against it.

Darwin has shown that small crustaceans and other animalculæ are found inside these bladders and that, since they cannot escape once they are caught, they die and decay. The decayed animal matter is absorbed by peculiar quadrifid hairs, found on the inner surfaces of the walls of the bladders.

My attention was drawn to a peculiar behaviour of this plant, when I was distributing specimens to my class for studying the structure of the bladders. As the specimens were lifted out of water to be placed in smaller dishes, they made light crackling sounds resembling the ticks of a watch. The sounds were unaccountable by anything I knew of the structure of the different parts of the plant. After a series of observations, they were located as coming from the bladders. The state of the bladders before and after lifting the plants out of water, gave the clue. When the plants had been allowed to remain quiet for two or three days in water, among the full grown bladders nearly 25 per cent. were found to be half filled with air and half with water. Nearly 50 per cent. were found to be completely filled with water and in some of these, the small organisms entrapped may be seen. The rest were nearly empty, with the walls closely adpressed against each other, so that there was very little cavity inside, and the bladder as a whole was biconcave.

The first two kinds of bladders with the walls convex and with the cavity inside filled with water or water and air, I will designate as "full." The last with its walls concave and with very little cavity, I will call "hungry." In every case the valve or trap-door was tightly pressed up against the rim of the mouth. When the plants were lifted up and replaced in water, there were very few hungry bladders left and in their places were now found some completely filled with water and others with water and air. There was no change in the full bladders. From this it

was inferred that the hungry bladders, when they were disturbed and came in contact probably with the leaf segments or other parts of the plant, opened out and let in water or water and air. Hence I suspected that the bladders were irritable and that the valve was very likely not simply a passive elastic door to be pushed in as Darwin supposed by an unwary or inquisitive animalcule, but an active trap-door which helped the bladder to forcibly suck in its prey.

As to the manner by which the animalcules make their way into the bladders, Darwin says " Animals enter the bladder by bending inwards the posterior free edge of the valve which from being highly elastic shuts again instantly. As the edge is extremely thin and fits closely against the edge of the collar, it would evidently be very difficult for the animal to get out when once imprisoned and apparently they never do escape. As I felt much difficulty in understanding how such minute and weak animals as are often captured, could force their way into the bladders, I tried many experiments to ascertain how this was effected. The free margin of the valve bends so easily that no resistance is felt when a needle or thin bristle is inserted. A thin human hair fixed to a handle and cut off so as to project barely $\frac{1}{4}$ of an inch entered with some difficulty, a longer piece yielded. On three occasions, minute particles of blue glass (so as to be easily distinguished) were placed on valves while under water and on trying gently to move them with a needle, they disappeared so suddenly, that not seeing what had happened, I thought I had flirted them off ; but on examining the bladders they were found safely enclosed. The same thing occurred to my son who placed little cubes of green boxwood on some walls and thrice in the act of placing them on or whilst gently moving them to another spot, the valve suddenly opened and they were engulfed. He then placed similar bits of wood on other valves and moved them about for some time and they did not enter." " To ascertain whether the valves were endowed with irritability, the surfaces of several were scratched with a needle or brushed with a fine camel-hair brush so as to imitate the crawling movements of small crustaceans, but the valve did not open. We may, therefore, conclude that the

animals enter merely by forcing their way through the slit-like orifice, their heads serving as a wedge." "But," says Darwin, "I am surprised that such small weak animals should be strong enough to act in this manner, seeing that it was difficult to push in one end of a bit of hair $\frac{1}{4}$ of an inch long." Darwin evidently came to the above conclusion quite half-heartedly and he missed the correct solution by a hair's breadth.

I will first corroborate Darwin's idea that it is unlikely that such small and weak animals should be strong enough to enter the bladders by pushing in the valve, and then try to explain the mystery of the particles of blue glass and boxwood. I tried to get an idea of the pressure the valve was able to withstand before it yielded and was pushed in. For this purpose, I used a spring which was fixed to a stand by one end. To its other end a piece of cork, with a small metal cup on its top and a needle stuck in at the bottom, was attached, so that the blunt end of the needle hung free. Below this was placed a Ziess's hand microtome which has a flat circular top, with a hole in the centre, through which the block-holder can be moved up and down by a micrometer screw. A bladder was cut across and the upper half, with the valve, was made to rest on its cut end, inside a narrow glass ring fixed to a slide. The ring was filled with water so that the cut bladder was immersed in water. The slide was placed on the microtome and slowly raised until the free end of the needle rested on the valve just touching it. Care was taken to see that the end of the needle did not come in contact with the ridge surrounding the mouth. The orifice was big enough to admit the end of the needle freely. Sand grains were now added to the metal cup until the lid just gave way. The weight of the sand grains which was 270 mg. gave an approximate idea of the pressure that the lid was able to withstand. This is likely not accurate, as here, the weight of the sand grains included not only the upward pressure of the valve, but also the weight necessary for the extension of the spring. To avoid it, as I thought, the action of the spring was reversed in this manner. The weight necessary for stretching the spring to a known distance was first calculated and then in the stretched

condition the needle was made to rest on the valve. Now the valve was gradually raised until it gave way. The distance to which the spring was raised to effect this, was made out and from it the weight supported by the valve was calculated. The weight thus got was 250 mg.

Now, let us consider the pressure the organisms can exert on the valve. Though it was not possible to get an accurate estimate, the following considerations, I expect, will give an approximate idea of the pushing force of the crustaceans and others, found inside the bladders. The force, that these organisms can exert, can be derived in three ways : firstly, their weight ; secondly, the momentum with which they dash against the valve ; and thirdly, the activity of their own muscles or any other structures corresponding to them.

The first factor, namely the weight, is quite negligible, since it will be greatly or fully counteracted by the buoyancy of water. As regards the second source, namely the momentum, the habit of these organisms, when they approach the bladders, is of great interest. I have spent a long time watching for the suction of the animals into the bladders. Whenever an animal approached a bladder, its quick motion was stopped and it went round as if it were brousing along in search of food and in no case was there an aimless or unwitting impact with the valve. Darwin says "It is difficult to conjecture what can attract so many creatures, animal and vegetable feeding crustaceans, worms, and various larvæ to enter the bladders. Perhaps small aquatic animals habitually enter very small crevices like that between the collar and the valve, in search of food or protection." My observations lead me to believe, though I am not yet in a position to prove definitely, that the attraction for these animals lies in the secretion of the clubheaded hairs found profusely near the base of the horse-shoe on the valve. Since the animals when they are near the bladder move about very slowly, the second source of energy is also not of any consequence. The third source, that of muscular power, is hard to get at and can only be guessed ; but a different consideration will, I think, put this source out of court. The distribution and direction of the long-pointed hairs round the ridge are such that entrance into the horse-shoe is

easy only through an arch formed by the antennæ or the very long branched hairs at the base of the horse-shoe. Now if an animal enters through this arch, it will necessarily come against the sharp points of the hairs which stretch from the apex of the valve towards this entrance. So it appears impossible for the animal to get at the edge of the valve and push it in. The above considerations, I hope, show that the presence of the animals inside the bladders cannot be due to their pushing their way in.

To see whether the suspicion that the bladders were irritable had any basis, the following experiments were done. First I selected some of the "hungry" bladders and irritated with a needle the different parts of the ridge, round the mouth and the valve. When the hairs at the apex of the dome of the valve were irritated, the adpressed sides shot out suddenly with a sharp explosive sound and the bladder got filled with water or air. I repeated this over and over again, so as to assure myself that I did not really push the valve in, but only irritated the hairs, and in the case of every hungry bladder the same reaction followed. No reaction occurred when any other parts of the region were irritated, so that I was able to assure myself that these particular hairs were the irritable hairs. Then I wanted to see whether similar conditions obtained when an animal was caught inside the bladder. It was found impossible to manœuvre the organisms to the bladders and, though I observed for a long time, I was not able to see an organism actually sucked in. But the critical question, whether a bladder is capable of sucking in the organisms if they irritate the hairs on the valve, was settled by another means. Once a dead fly, more or less in a putrifying condition, was found floating on the water in one of the dishes. I took the front half of the fly at the tip of a needle and irritated the hairs of a hungry bladder with the head of the fly. To my joy, the whole object was immediately sucked in. This set at rest my doubts as regards the capacity of the bladders to suck the organisms in, as the biggest of the crustaceans found inside were not more than $\frac{1}{3}$ of the head of the fly in size.

I wish to draw attention to the fact that the above experiments were done with the hungry bladders only. The full bladders

do not react to irritation. This explains the mystery of the disappearance of the particles of blue glass and boxwood in some cases and not in others. I take it that the bladders that swallowed the particles were 'hungry' and those that did not were 'full.' The same fact also explains the negative results obtained by Darwin when he irritated the bladders, as nearly 75 per cent. of the bladders in a plant are in the 'full' condition and the 'hungry' bladders are generally very few. It may also be due to the fact that the reaction to irritation is extremely quick and easily escapes notice.

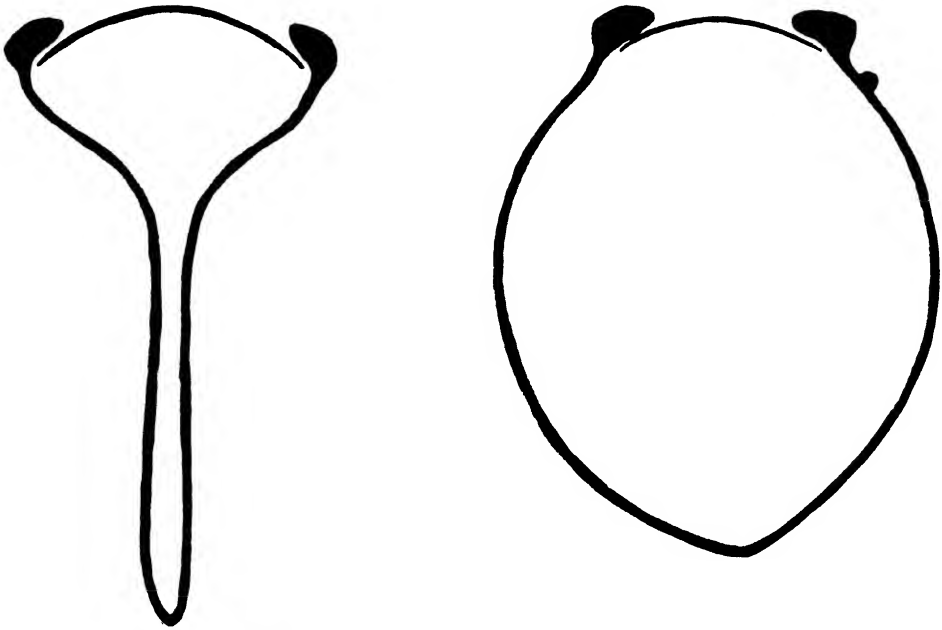
A few words about the mode of action under irritation. Owing to the quickness of reaction, it is impossible to observe directly the opening and closing of the valve. When the valve of a full or non-hungry bladder is pressed down with a needle as far as it could go, the irritable hairs project right in the centre of the opening. If an animal is sucked in when the valve is in this position, it should be either impaled on the hairs or the hairs should be broken. But I could never believe, that in such a delicate mechanism, this flaw could ever occur. The explanation was arrived at rather accidentally. In an idle mood I pressed out the contents of a full bladder with a pair of pincers. The contents came out through a slit formed by a portion of the margin of the valve being pushed out. When the pressure was relieved, the valve fell back quickly to its place and no water entered from outside ; but some air escaped from the intercellular spaces in the walls of the bladder and filled up the cavity. Then, I once again pressed out all the air and over again when more air came in. When the air was driven out twice or thrice, the bladder assumed the hungry condition. When I irritated the hairs, it reacted in the normal manner. I got very much interested and the whole operation was thrice repeated with the same bladder. The valve went in once again under irritation but never came back and the bladder was left wide open. When I looked through the open mouth, I could not see the irritable hairs and the passage was perfectly clear. It was then that the proper position of the irritable hairs, when reacting to irritation, was shown. On examination, it was found that the convex valve had become concave and boat-shaped, and the hairs were found safely

PLATE IX

Fig. 1. Longitudinal section at right angles to the plane in plate II, fig. 2. The left-hand diagram shows the "hungry" condition with the walls concave and adpressed. The right-hand one shows the "full" condition with the walls convex.

Fig. 2. Median longitudinal section, showing the position of the valve when the bladder opens under irritation. The valve is concave and drawn back and has the irritable hairs laid in the hollow.

PLATE IX.



a Fig. 1 b

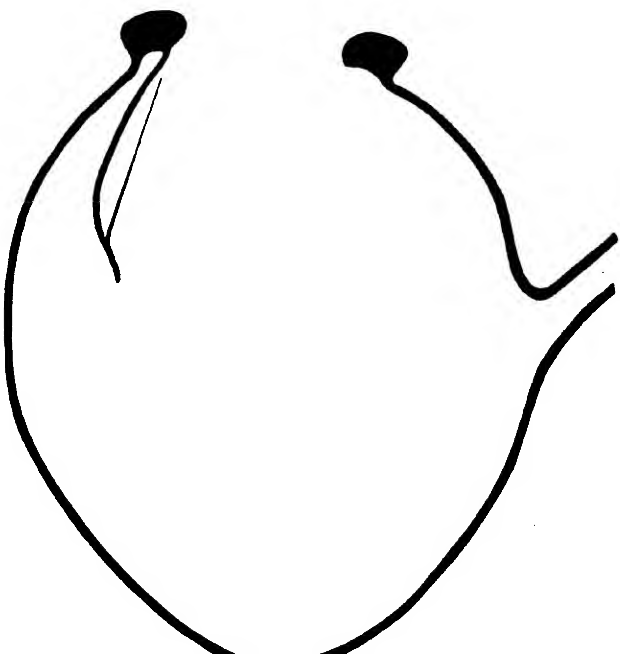


Fig. 2.

laid at the bottom of the boat. The orifice was fully open without any obstruction. (Plate IX, fig. 2.)

The nature and arrangement of the cells that go to make up the valve, the irritable hairs, and the ridge are very interesting. Their relation to the functions performed is under investigation.

MODELS TO ILLUSTRATE SEGREGATION AND COMBINATION OF MENDELIAN CHARACTERS.

BY

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It is not proposed in this paper to expound the principles of heredity discovered by Mendel. My object is merely to explain the working of models devised by me to demonstrate the behaviour of hereditary characters that conform with Mendel's principles, as they are transmitted from one generation to another.

I have taken glass beads to represent the determiners of hereditary unit characters. A coloured bead is used to represent the determiner of a dominant character. A colourless bead of the same shape and size is used to stand for the corresponding recessive, if the presence and absence hypothesis of dominant and recessive characters is to be illustrated. A certain modification of the entire model is devised to illustrate the working of the determiners of heredity, when the recessive ones are supposed to have a definite existence.

I have represented the idea of there being two determiners or a double dose of a dominant character in an individual by taking two coloured beads which are in every way identical. The single dose condition is represented by two beads of the shape and size but only one of them is coloured while the other is colourless. The nil dose or recessive condition is represented by two uncoloured beads. The use of any beads whatever to represent recessive determiners when they are conceived to have no existence at all is

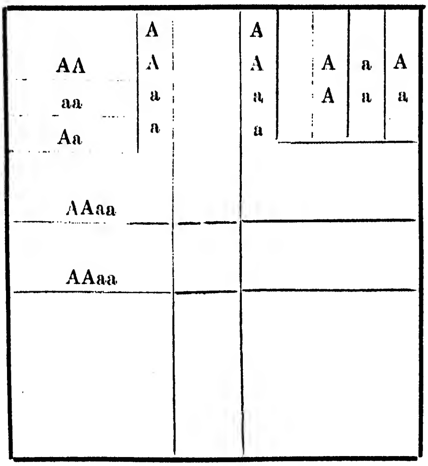
justified only on the score of convenience afforded in working the model.

The idea of indivisibility of the determiners and their segregation in the sexual cells involves the reduction in the sexual cells of a double dose when it is present in an organism to a single dose, and the formation of two sorts of sexual cells in equal numbers one carrying a single dose and the other a nil dose when the organism itself has got only one dose. This implies the existence of sexual cells of only two types with reference to a given determiner, one type carrying a single dose of it and the other none of it. Thus there are three types of organisms represented by the conventional symbols **A A, A a,** and **a a,** and called homozygous or pure dominant, heterozygous or hybrid dominant, and recessive which is always pure; but there are only two types of sexual cells, *viz.*, **A** and **a.** This fact is generally embodied in the doctrine of purity of gametes. Segregation is commonly spoken of in Mendelian literature, following Mendel's own conception of "pairs of differentiating characters and their mutual separation in the sexual cells" as "the dissociation of the allelomorphic or alternative characters in the constitution of the gametes," or symbolically the separation of A a from each other. The separation of A A and of **a a** (Mendel conceived of **a a** not as an absence but as a presence) also from each other was not noticed by Mendel, and has also apparently escaped the attention of most writers on Mendelism. The composition of different zygotes and of their gametes with reference to one character may be represented thus—

Zygotes	A A	A a	a a
Gametes	all A	A and a in equal numbers	all a

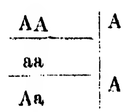
In my model which consists of a square frame work standing erect and carrying strings of beads the composition of the different types of organisms and of the gametes is shown by beads on different strings. The strings carrying the beads for gametes of one parent cross those of the other parent, and the composition of the resulting zygotes is shown by moving the beads to the points of intersection.

The following diagram which deals with the consideration of one character only will render clearer what I have just stated.



Note. The beads in the top left-hand square represent the zygotes and those in the top right-hand square the gametes produced by these zygotes.

It may be further simplified as given below which requires only fourteen beads in all.



When two characters are considered conjointly there would be nine (3^n, n being the number of characters considered as stated by Mendel), different forms of zygotes represented by the symbols AA BB, AA bb, aa BB, aa bb, AA Bb, Aa BB, Aa bb, aa Bb and Aa Bb, and there would be four (2^2) different forms of gametes, *viz.*, AB, Ab, aB and ab.

In the model the strings of beads representing the gametes should be in pairs, one string for the determiners of each character. Since there are four different forms of gametes there should be four pairs of strings. The four vertical pairs would cross the four horizontal ones and thus there would be sixteen groups of crossing, each group consisting of four crossings. The formation of zygotes is represented in the central square by moving the requisite beads to the points of intersection. If it is desired to reproduce the conventional arrangement when demonstrating the effect of selfing of AaBb or of crossing of a zygote AaBb with another which is also AaBb, the four types of gametes on the four pairs of strings should be arranged in the order **AB, Ab, aB** and **ab** from left to right on the vertical strings, or from above downwards on the horizontal strings.

In the demonstration of the working of three characters taken conjointly, there would be twenty-seven (3^3) possible forms of zygotes to be considered. These may be arranged as follows though any other order would serve the purpose.

Group I	AA BB CC		
,, ,,	AA BB cc	AA bb CC	aa BB CC
,, ,,	AA bb cc	aa BB cc	aa bb CC
,, ,,	aa bb cc		
Group II	AA BB Cc	AA Bb CC	Aa BB CC
,, ,,	AA bb Cc	aa Bb CC	Aa BB cc
,, ,,	aa BB Cc	AA Bb cc	Aa bb CC
,, ,,	aa bb Cc	aa Bb cc	Aa bb cc
Group III	AA Bb Cc	Aa BB Cc	Aa Bb CC
,, ,,	aa Bb Cc	Aa bb Cc	Aa Bb cc
Group IV	Aa Bb Cc		

In the model, **ABC** are represented by three kinds of beads which differ in colour, shape, and size, and **abc** by corresponding beads which are colourless. The twenty-seven genotypes fall into four groups according to their behaviour in breeding when selfed and I have assigned to each of them a separate corner in the model. In the first group there are eight genotypes which are quite constant. These are placed in the left-hand top corner. The second group which contains twelve forms includes genotypes in which one of the three characters will split. The third group of six forms contains two of the three characters splitting. The last group which contains

only one form has none of the characters constant. The above grouping also brings out the frequency of the occurrence of different forms when Aa Bb Cc is selfed. The resulting combinations form a series of 64 in which the eight genotypes of the first group appear once only, the twelve genotypes of the second group appear twice only, the six types placed in the third group appear four times, and lastly, the single type in the fourth group appears eight times The following table makes this point clear :—

8×1	8
12×2	24
6×4	24
1×8	8
	64

If it is desired to bring out the phenotypic composition as well, it may be done by adding eight squares to the model in any fashion whatever. I would suggest their provision in an oblong frame with eight compartments added to the model at the top of it. The twenty-seven genotypes may be arranged in eight phenotypic groups as follows :—

1. Phenotype ABC having eight genotypes.

AA BB CC		
AA BB Cc	AA Bb CC	Aa BB CC
AA Bb Cc	Aa BB Cc	Aa Bb CC
Aa Bb Cc		

2. Phenotype ABc having four genotypes.

AA BB cc　AA Bc cc　Aa BB cc　Aa Bb cc

3. Phenotype AbC having four genotypes.

AA bb CC　AA bb Cc　Aa bb CC　Aa bb Cc

4. Phenotype aBC having four genotypes.

aa BB CC　aa BB Cc　aa Bb CC　aa Bb Cc

5. Phenotype Abc having two genotypes.

AA bb cc　Aa bb cc

6. Phenotype aBc having two genotypes.

aa BB cc　aa Bb cc

7. Phenotype abC having two genotypes.

aa bb CC　aa bb C

8. Phenotype abc having one genotype.

aa bb cc

So far I have dealt with simple factors. An effective demonstration of complementary factors is obtained by using tiny bits of sponge dipped in appropriate chemical solutions instead of beads. Thus bits of sponge dipped in phenolphthalein and caustic potash solutions may be used to demonstrate the production of coloured flowers by crossing two white forms. Other phenomena of Mendelian inheritance such as cumulative factors, inhibitory factors and gametic coupling can as well be demonstrated on the same principles. I propose to deal with these in detail in a subsequent paper, as also with the modification required to be made when the recessive characters are supposed to be due to the presence of definite recessive determiners.

THE CORRELATION OF RAINFALL AND THE SUCCEEDING CROPS WITH SPECIAL REFERENCE TO THE PUNJAB.*

BY

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Introductory. In the first application of the method of correlation to the problem of the numerical measurement of the dependence of crops on rainfall in India, only the general effect of the whole summer and winter rainfalls on the autumn and spring harvests respectively was considered. In the present paper the effect of the distribution of rainfall in time is more specifically dealt with, and, too, the more important crops have been treated separately; both being very necessary steps towards the complete determination of the character of the harvest from the antecedent rainfall.

Increasing attention has been devoted of late years to attack on the same problem by similar methods in other countries, more particularly in America, and there has been obtained a sufficient number of high coefficients of correlation to encourage further investigation on the same lines.†

* This paper is also published as a Memoir of the Meteorological Department of the Government of India.

† The more notable values obtained hitherto are :—

(1) A double correlation coefficient of +·80 of Spring rain and accumulated temperature with outturn of hay from clover and rotation grass for Eastern England. Hooker.—*Journal Roy. Stat. Soc.*, 15-1-1907.

(2) A total correlation coefficient of +·73 between the rainfall of October to March and the unirrigated matured area of the Spring harvest for the Sialkot district of the Punjab, and a double correlation coefficient of +·80 for similar data for the Delhi district. Jacob.—*Memoirs of the Asiatic Society of Bengal*, 3-2-1909.

(*Continued on page* 87).

The tract selected: Jullundur Tahsil. The tract I have dealt with is the Jullundur Tahsil of the Jullundur District situate in the Doaba between the rivers Beas and Sutlej. The area of the Tahsil is 428 square miles of which practically 390 are cultivated, and it is divided into three Assessment Circles, which are roughly homogeneous in respect of their soil, climate, and their courses of husbandry. There are no canals and as a rule very little flooding, so that the problem of rainfall effect is not too complicated. But there is a very large number of wells, and during the last 30 years more wells have been steadily added to both the Dona Lehnda and Dona Charhda Circles, and this means that there is a concomitant diminution of unirrigated crops, for which allowance has to be made in considering the variation in the areas sown each harvest on unirrigated land. Thus in the Dona Charhda Circle every fresh well sunk has meant that on the average 2·2 acres cease to be classed as unirrigated for the purposes of the Spring harvest. Of this diminution a loss of :—

0·66 acres per new well falls on unirrigated					wheat sown,
1·20	,,	,,	,,	,,	wheat and gram,
0·18	,,	,,	,,	,,	gram alone,

and the balance of ·16 acres on other crops.

The countervailing gain in Spring irrigated crops is however no less than an additional 7·4 acres for each additional well, of which 3·36 acres per well, or rather less than one-half, has been an increase in wheat sowings. Before the correlation of the areas sown with the rainfall are worked out, the crude figures must in all cases be corrected by the appropriate factors, these being slightly different for each of the three Assessment Circles.

Distinction between the two problems—sown area and yield. Two entirely distinct problems present themselves if we propose

(3) A correlation of −·69 between accumulated temperature and potato yield Warren Smith.—*U. S. Monthly Weather Review*, May 1911.

(4) A correlation of −·70 between the effective rainfall of July 21 to August 20, and the yield in corn in Ohio. Warren Smith —*U. S Monthly Weather Review*, February 1914.

(5) A correlation of ·88 between rainfall and temperature in April to September and the yield of cotton in Texas. J. B. Kincer —*U. S. Monthly Weather Review*, February 1915.

to forecast the amount of crop of any harvest, and these are :—

(1) The determination of the area sown with each class of crop.

(2) The determination of the percentage of the crop which is likely to come to maturity, or, in other words, the yield or outturn per unit of area.

The first problem, which is, for not too great a cycle of years, in the main a problem of rainfall and temperature, is also an economic and psychological problem—prices of seeds, scarcity of labour, population, mortality, the standard of living, the number of plough cattle, mechanical aids to cultivation, and political events—all having contributory effects. Yet, unless the fluctuations in these subsidiary causes are very violent, they will not mask the first order effect of rainfall, and the proper method is to deal with the large effects first, and then proceed to disentangle the residual effects. This is the invariable scientific practice in those cases, for example in astronomy, in which we cannot control the phenomena.

The second problem, the determination of the yield of each crop per acre, is much less an enonomic problem than the preceding one, especially in dealing with unirrigated crops which are not much manured or weeded, and is really a joint problem of meteorology, subsoil physics, and plant biology. It is a statistical problem only on account of its complexity ; and the more physical and biological laws can be applied to it, the smaller will be the residual unexplained effects to which it will be necessary to apply statistical methods.

Prediction of areas sown.

Correlation of rainfall and sown areas. I take first the problem of predicting the extent of sowings, and give the total correlations of some only of the crops which have been considered for each Assessment Circle, namely, for *chahi* (well-irrigated) wheat, wheat and gram unirrigated, and all unirrigated crops together, for the Spring harvest based on the figures of the thirty years 1886-1915.

The correlations are :—

		July	August	September	October
Chahi wheat ...	Dona Lehnda ..	−0·38	−0·25	−0·52	......
	,, Charhda ...	......	−0·28	−0·53	−0·34
	Sirwal	... ..	−0·01	−0·50	−0·39
Barani wheat and gram.	Dona Lehnda ...	0·18	0·21	0·54	...
	,, Charhda ...	.. ...	0·13	0·54	0·19
	Sirwal	......	0·16	0·27	.. ..
All Barani Spring crops.	Dona Lehnda ...	0·21	0·04	0·37	...
	,, Charhda ...	... ..	0·17	0·48	0·33
	Sirwal	......	−0·06	0·48	... ..

The July and August coefficients are in the neighbourhood of 0·20 with a probable error of ± 0·12, or, on the simple theory of probability, the odds in favour of these correlations being significant are 7 to 1. The simple theory, however, by no means gives a favourable enough estimate of the odds when we find coefficients of about the same magnitude repeated again and again. In fact the repetition of the correlations for three different areas, supposing the sown areas in each case are unassociated except on the score of a more or less common rainfall, makes the odds nearly 350 to 1. So that I think that we may justly conclude that the correlations with July and August rainfalls are significant. In any case it is highly probable that they are significant, as the rainfall in these months is a true contributory cause of the autumn sowings of September, October, and November.

The correlations of sown area with September rain are in the neighbourhood of 0·50 with a probable error of ± 0·09, so that the simple odds in favour of the significance of this correlation are over 80,000 to 1, so that this coefficient is undoubtedly significant. The frequency with which nearly the same value of the correlation is found for this and other districts of the Punjab makes the odds much greater even than this.

The correlations for October are on an average about 0·23 with a probable error of ± 0·11, or the odds in favour of their significance are 18 to 1.

A further point of importance with regard to the correlation with September rain is that the odds are 9 to 1 against its being as

low as 0·325, and we are not likely to be wrong if we say that it lies between 0·4 and 0·6. For lower correlations we cannot predicate such narrow limits between which the correlation coefficient is likely to lie.

The coefficients are the simple or so-called total correlation coefficients, but they do not represent the actual rainfall effect and it is necessary to eliminate the error due to the fact that the rainfalls in the different months are themselves correlated, and so it is possible that the area sown is spuriously correlated with the August rainfall simply because it happens to depend on the September rain, which in its turn is correlated with the August rainfall.

If the rainfalls in August, September, and October (July rainfall has been left out of account because of the doubt of the magnitude of its effect on autumn sowings) are positively correlated *inter se*, then this fact will have given a fictitiously high value to all the correlations ; but, if on the other hand the rainfalls are negatively correlated among themselves, the true magnitude of the crop correlations will have been masked, and we may have considerably to increase the total correlations previously found. This latter is actually the case. The correlations of the rainfalls are :

August with September	−0·37
,, ,, October	−0·10
September with October	−0·13

So that it is clear that the true or so-called net coefficients of correlation are markedly larger than the values previously stated. The valuation of the net coefficients of correlation is a somewhat laborious process, and for the Jullundur data I have limited myself to the two cases of greatest interest, namely, for well-irrigated wheat and for all unirrigated crops together.

Prediction for Chahi wheat. I take firstly the case of well-irrigated wheat in the Dona Charhda Circle for which the average area sown in the last 30 years is 19,100 acres, with a standard deviation of 4,080 acres or 21·3 per cent. The net correlations of the area sown each autumn are as follows :—

With August rainfall	−0·79
,, September ,,	−0·86
,, October ,,	−0·74

These average at about 0·80 with a probable error of ± 0·08, and the odds are thus over 20 to 1 against the coefficients being as low as – 0·60 in absolute value, and nearly 200 to 1 against their being as low as – 0·5, so that we may say that these coefficients are almost certainly greater than 0·6.

From these correlations we determine the equation expressing the area sown with wheat on well-irrigated lands in terms of the rainfall departures from the mean, namely :—

$$S' = 18,890 - 570\ D_8 - 750\ D_9 - 4,300\ D_{10},$$

where D_n is the departure of the rainfall of the *n*th month from the average rainfall of the month.

The equation shows what an enormous effect rain in October has in causing the cultivator to abandon wheat sowings on well-irrigated lands : in fact an inch of rain in October would throw out nearly 6 acres of well-irrigated wheat, as against one acre thrown out by an additional inch of rain in August.

The equation must not, however, be interpreted to mean that every successive increment of rain will throw out further equal amounts of well-irrigated wheat, as the relation between the rainfall and the area sown is certainly not linear when we come to large departures from the average. All that we can assert from the equation is that rainfall of the quantity and distribution that fell during the years 1885—1914 in August, September, and October did, on the whole, have the effects noted. Of course in considering what effects rainfall in the different months has on well-wheat sowings we must remember that it is much more usual to have a departure of one inch of rain in August or September than in October, and properly to compare the effects of rainfall as it did occur in the last thirty years we must multiply the regression coefficients of each month by their respective average rainfalls. We find thus that actually the relative effects of August, September, and October rainfall were as 2 : 3 : 1, the reason for the low October effect being due to the fact that it is the exception to get rain in October at all. If it does fall it has, as we have seen, a much greater effect than rainfall in the previous months in diminishing sowings of well-irrigated wheat.

When the appropriate correction for the number of wells has been introduced the final formula of prediction for the sown area of *chahi* wheat is :—

$$S = 3{\cdot}6\,(w-5540) + 26{,}910 - 570R_8 - 750R_9 - 4300R_{10},$$

where R_n is the total rainfall in the *n*th month, and w is the number of wells in the Assessment Circle.

The multiple coefficient of correlation of sown area and the 'weighted' area is 0·89, so that the prediction formula, so far as a linear expression can give the relationship, is a good one.

From this formula the sown area has been calculated for each year from 1885—1914 and the results are shown graphically in Diagram I, which shows also the actual sown areas.

The correspondence between the observed and calculated results is seen to be distinctly close. The probable error of the prediction is $0{\cdot}67 \times \sigma_{1\cdot234} = 1050$, or 5·6 per cent. of the mean.

Constancy of other crops. A very important fact may here be referred to, namely, that if we group together all well-irrigated Spring crops excluding wheat, and wheat and gram and form a class of 'other crops' which consists mainly of the fodder crop, senji, melon, tobacco, and other vegetables,* the sown area of this class after the correlation for numbers of wells has been applied is remarkably constant from year to year having a coefficient of variation of only 5·9 per cent. as against one of 21·9 per cent. for well-irrigated wheat, so that the prediction from an appropriate rainfall formula would have a probable error of about 2 per cent. only.

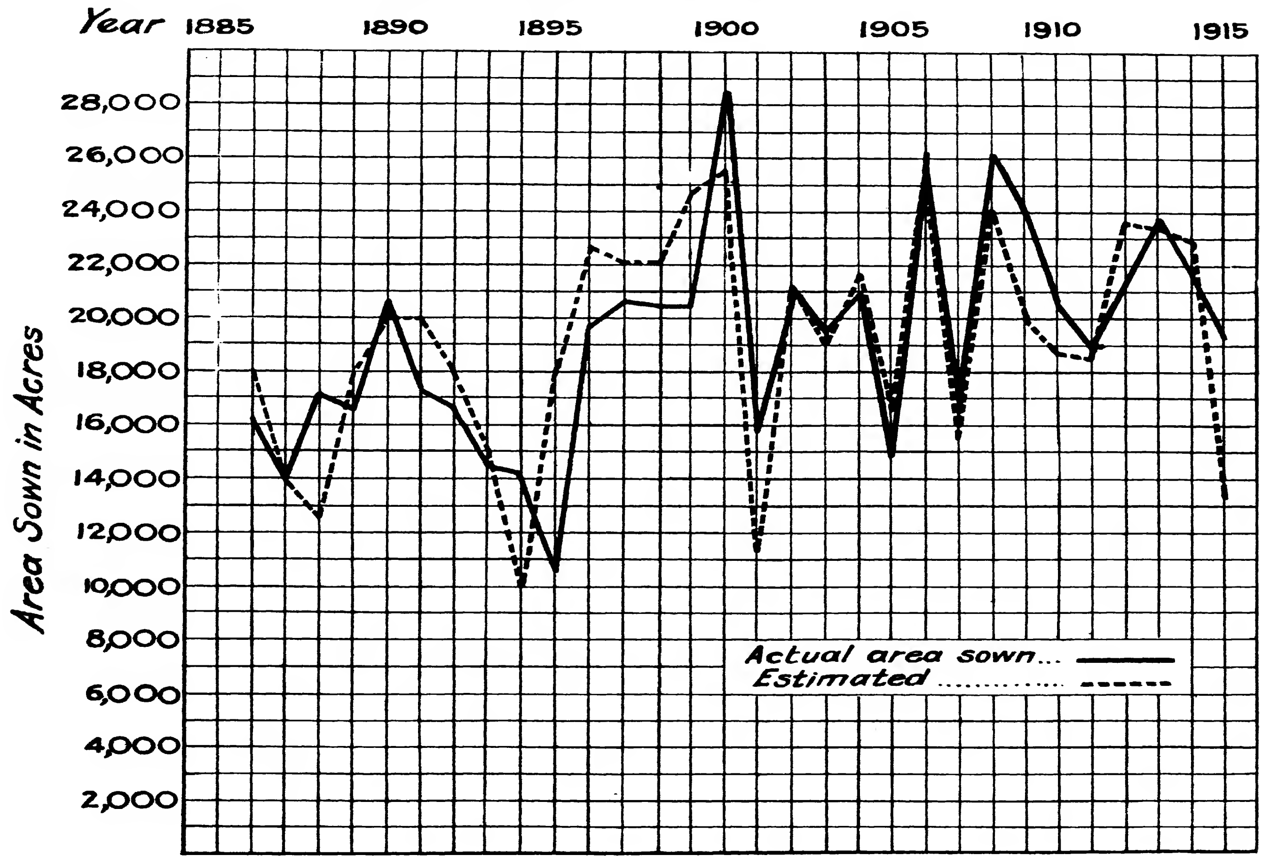
Prediction for all barani rabi crops. The next case treated is that of all unirrigated (*barani*) Spring crops taken together.

The prediction of the sown areas of individual unirrigated crops is very desirable, but except for the principal crop, wheat and gram combined, the problem will require a finer analysis than by the total rainfall of the month. Thus the 30th of September is a critical time. If sowing conditions are favourable before that date, a great deal of gram is likely to be sown, but if suitable rain falls after that, gram is almost always combined with wheat. Wheat

* This group of crops consists of those grown for local consumption of man and beast and are very little affected by external supply and demand.

DIAGRAM I.

Dona Charhda CHAHI WHEAT.



in particular requires very favourable conditions if it is to be sown on *barani* land, and an examination of monthly rainfall does not suffice to show the fluctuations in the area sown, which in all three parts of the Tahsil shows a steady fall from 1885 onwards with a minimum between 1900 and 1905 and a very marked rise in the last 10 years.

The regularity of the change suggests a secular cause such as Dr. Shaw's 11 years' periodicity from wheat in England. At any rate the general trend of the data can be fitted with a smooth curve.

Parabolas fitted by the method of least squares are fair representations, but would certainly break down for extrapolation purposes.

For the sown areas of all unirrigated Spring crops together the net correlation coefficients are :—

With August rainfall	= + 0·57
,, September ,,	= + 0·72
,, October ,,	= + 0·59

The combined coefficient of correlation is 0·77 so that fair prediction is to be anticipated. Taking the coefficients of the linear regression formula, and multiplying them by the appropriate constant, the expression

$$\cdot 147\ R_8 + \cdot 53R_9 + 2\cdot 66R_1$$

is obtained which may be called the weighted rainfall. If the weighted rainfall is taken as the abscissa and the area sown corrected for the number of wells as ordinate we get a distribution of the kind as shown in Diagram II which clearly indicates that to a second approximation the data can be fitted with a curve of the form

$$y^n = ax - bx^2,$$

and after a number of trials the curve

$$y^3 = 34x - 1\cdot 7x^2$$

was found to be a fair but not a good approximation to the changes. The curve rises abruptly at the origin, but it would have been better to make it rise abruptly at 2″ of the rainfall, which is about the minimum required for any sowings at all. It reaches a maximum at 30″ of weighted rainfall, that is to say,

beyond that, more rainfall would interfere with sowings. About the same maximum was found for data in the old Delhi District. The problem however must be attacked by a systematic curve-fitting method, which should substantially reduce the probable error of prediction which is $0{\cdot}675 \times 5700 = 3840$ acres or 9 per cent. of the mean, an appreciably larger error than in the case of irrigated wheat, although the coefficient of variation is about the same, 22 per cent., in both cases. Even as it is, the prediction afforded is a distinct advance on existing practice.

Prediction of Outturn.

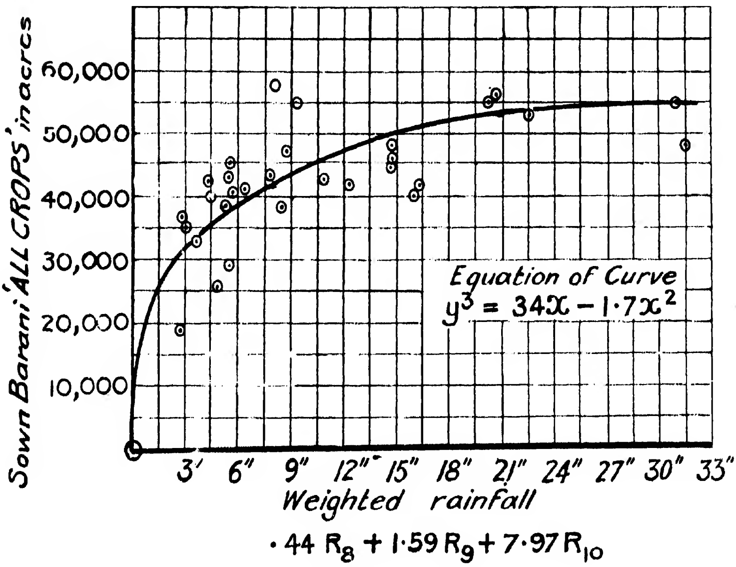
Nature of problem. The next step after finding out how much crop is sown is to find out how much of it is going to come to maturity, and that is as for human beings, both a bathmic and an environmental problem, condition of seed, state of the seed bed, and the treatment and climate from the time of sowing to the time of harvesting, being the factors to be taken into account.

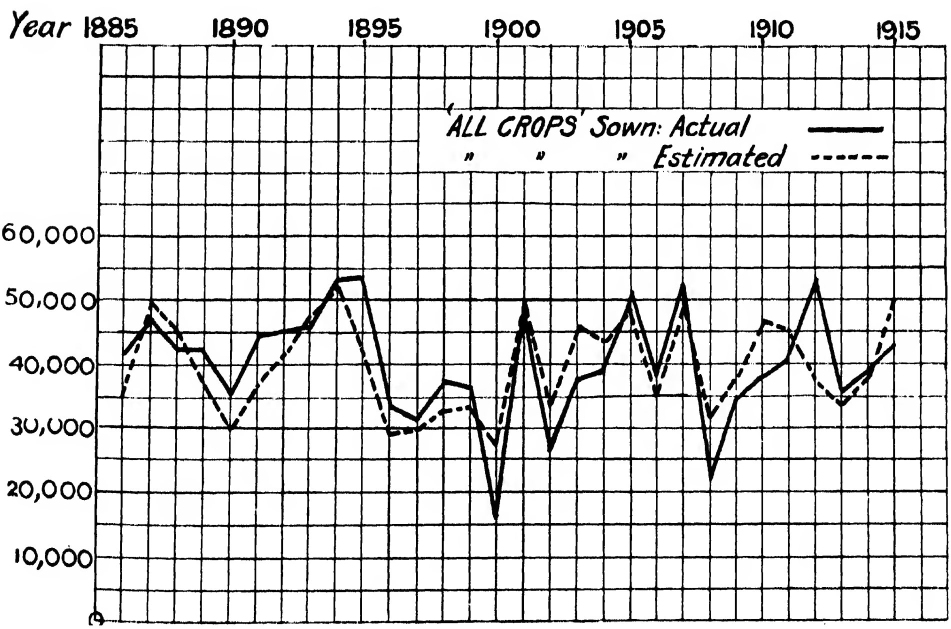
In the present paper unirrigated wheat only is dealt with by the statistical method, and the condition of seed has not for the moment been taken into account; but the state of the seed bed which depends, in the main, on the September and October rainfall, is taken into account as well as the rainfalls in each of the subsequent winter months, November to March.* The antecedent rotational crop which is a very important factor in considering individual fields is a quite subsidiary point in the aggregate over such a large area as an assessment circle, in which there will be many fields in different stages of the crop rotation. As a matter of fact, unirrigated wheat is generally sown after a 10 months fallow and is followed by *charri*, *moth*, or *guara*, in the subsequent June or July (*dofasli dosala*) or on the better class of unirrigated (*barani*) soils, wheat is sown year after year (*ek fasli ek sala*) with no intermediate crop. The outturn is determined in the Punjab Revenue Papers from the

* An analysis which aimed at completeness would naturally include not merely rainfall but all climatological factors, such as temperature, sunshine, precipitation in the form of dew, evaporation, wind, and so forth, defect or excess of which may on occasion reduce an otherwise promising crop to a very poor condition. Given the opportunity the analysis can be so completed.

DIAGRAM II.

Dona Charhda ALL BARANI RABI CROPS SHOWN.





area of the crop which fails to come to maturity, the so-called *kharaba* which is merely the Patwari's estimate of the deficiency of the particular field below what he considers a normal value.

His estimate is checked by various Revenue officials of higher grade, but it still remains subject to a very large personal equation. In particular during the last 15 years there has been much greater liberality in allowing *kharaba,* and in dealing with the statistics the last 30 years have been divided into two periods. The results based on the second period are probably the more reliable. Crop experiments are, as at present conducted, of a very perfunctory kind, and two or three of them for each principal crop per Tahsil, would be required to get results truly indicative of the character of the harvest. It is much to be regretted that a proposal to do away with crop experiments altogether has been mooted. It is quite as important that accurate outturns should be determined for crops grown by cultivators under normal conditions, as for crops grown for special test purposes by the Agricultural Department.

Prediction by multiple correlation. Taking the figures for *kharaba* as we have them the correlations of rainfall and failed area for the various crops are :—

Correlations of percentage kharaba with rainfall in the winter months.

	Assessment Circle	September	December	January	February	March
Chahi wheat ...	Dona Lehnda ...	......	-0·36	-0·19	-0·27	-0 27
	,, Charhda ..	-0·41	-0·46	+0 01	-0·21	-0·36
	Sirwal ...	.. ...	...	......	......	...
Chahi all crops ...	Dona Lehnda .	......	....	......	..	.....
	,, Charhda . .	-0·46	-0·39	-0·18	-0·25	-0·43
	Sirwal ...	-0·08	-0·05	+0·17	-0·02	-0·15
Barani wheat ...	Dona Lehnda ...	...	-0·31	-0·16	-0 19	-0 07
	,, Charhda	-0·37	-0·40	-0·16	-0·26	-0·26
	Sirwal ..	-0·12	-0·07	+0·23	-0·02	-0·14
Barani wheat gram ...	Dona Lehnda	...	-0·13	-0·14	-0 19	-0 23
	,, Charhda ...	-0·37	-0·34	-0·19	-0·31	-0·35
	Sirwal ...	-0·54	-0·33	-0·11	-0·37	-0·41
Barani gram ...	Dona Lehnda ..	......	......	...	......	.....
	,, Charhda ..	-0·43	-0·51	-0·19	-0·31	-0·35
	Sirwal ..	...	...	.. .	... .	...
Barani all crops .	Dona Lehnda ..	... ..	-0·23	-0·20	-0·14	-0·22
	,, Charhda ...	-0·40	-0·40	-0·17	-0·32	-0·24
	Sirwal ...	-0·42	-0·32	-0·07	-0·26	-0·23

The Dona Lehnda results are for the 30 years 1886-1915. For Dona Charhda and Sirwal for 1901-1915.

A noticeable feature of the figures is the high negative correlation with September rainfall, additional evidence, were any necessary, of the value of a moist seed bed for germination.

I have not had sufficient time at my disposal to discuss in great detail the results for all three Assessment Circles, and for this reason it was necessary to limit the further analysis to a single crop and a single assessment circle. Accordingly the most important crop, wheat, has been selected, and that Assessment Circle in which the rain gauge is situated.

I emphasize only the Dona Charhda figures for unirrigated wheat which are :—

	September	December	January	February	March
Whole period 1886—1915 .	-0·30	-0·30	-0·27	-0·19	-0·24
First „ 1886—1900 ...	-0·25	-0·25	-0·46	-0·02	-0·19
Second „ 1901—1915 ...	-0·37	-0·40	-0·16	-0·26	-0 26

These figures are consistent *inter se* and with all the other Circles and crops and their significance is accordingly greater than it would be if measured merely by their probable errors.

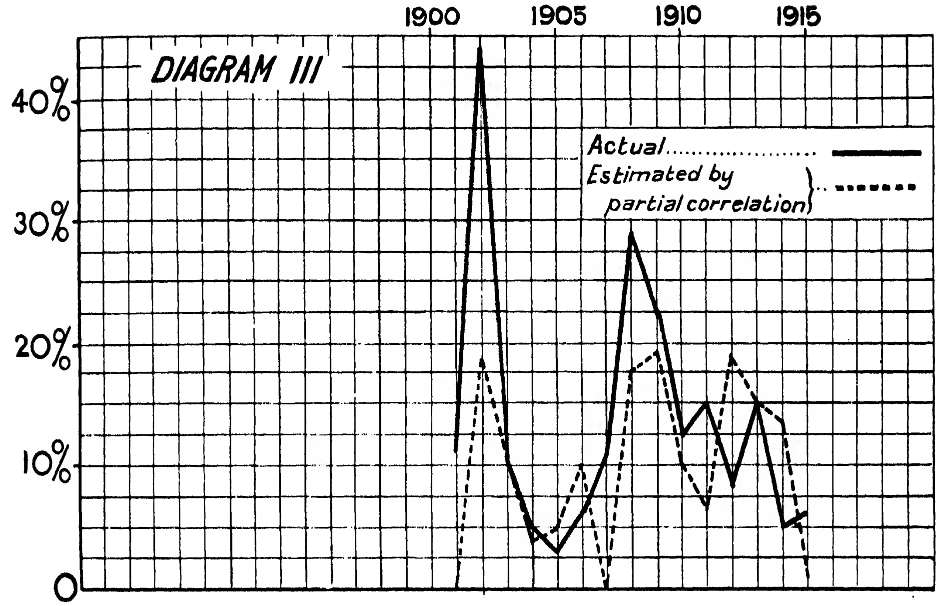
On the figures of the last 15 years I have calculated a provisional regression formula based on the erroneous assumption that the rainfalls in these five months are not correlated to each other.

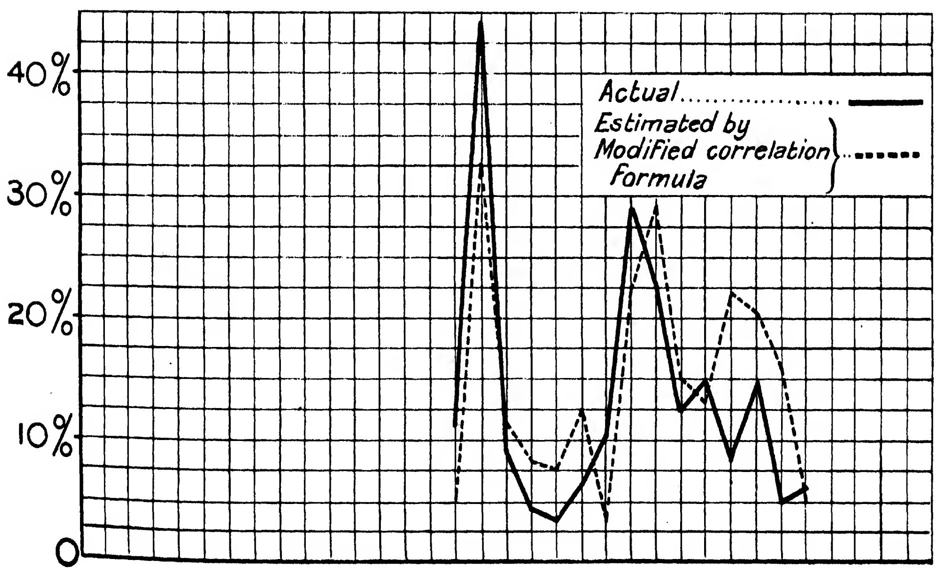
Actually there is no significant correlation between the rainfalls of December and February, January and February, February and March.

In fact the February rainfall seems a very detached effort, but there is a substantial correlation in the rainfalls in the other months. The concordance between calculation and fact is shown in Diagram III. The agreement would have been much better had these mutual rainfall correlations been taken into account, but a multiple regression formula based on six variables takes a long to evaluate time and on account of pressure of much other work I had to abandon it.

Kincer's method. Moreover, Dr. Simpson having drawn my attention to an alternative, and in some ways a preferable method

Dona Charhda. WHEAT KHARABA.





of dealing with the problem, developed by J. B. Kincer in the *U. S. Monthly Weather Review* of February 1915 for dealing with the yield of cotton in *Texas,* it seemed of importance to apply the method to yields of Indian crops. Kincer's results being so good that a correlation of 0·88 is obtained.

Kincer assumes that the most favourable conditions for cotton are the normal ones, and that any departures from these, whether above or below, whether of rainfall or temperature, are harmful. There would seem to be *a priori* justification for this in dealing with a crop with centuries of development in a single place behind it, but expert opinion would be advisable before adopting it for Indian crops particularly for imported plants.

Kincer adopts certain numerical values for the harm done by rain, or heat, or cold, according as a plus deviation follows a plus deviation, a minus a minus, and so on, thus :—

	Rainfall					
	April	May	June	July	August	September
+ following + or 0 ...	4	8	8	4	4	4
+ ,, − ...	4	4	2	2	2	3
− ,, − ...	4	5	6	8	10	8
− ,, 0 or + ...	2	2	3	6	8	4

Naturally a sequence of months with the same departure from normal is weighted as the most harmful.

He has a similar table for temperature :—

	April	May	June	July	August	September
+ Temperature with 0 or + rain.	1	1	1	1	1	1
+ T with − R	1	1	2	2	2	1
− T with − R	1	3	2	2	2	2
− T with + R	1	4	4	2	2	2

He has in addition certain slight modifications of the value to be introduced when during several months the same conditions obtain.

The values are stated "to have been fixed empirically from a general knowledge of the effect or plant development of certain combinations of weather," but what constitutes a plus, zero or a minus departure is not stated except that 0·3 of an inch of rain less than the normal for April or May is considered as minus.

Application of Kincer's method to unirrigated wheat. In applying Kincer's method to the yield of unirrigated wheat in Jullundur District, it seemed much better to assume that all departures of rain above the normal are beneficial and *vice versâ,* not because this is true for all crops in all places, but because with the soil and rainfall which actually obtain in that district, it is very rare for excess of rain to be markedly harmful.

In order to make the scheme as little arbitrary as possible the rainfall distribution curves have been plotted for each month, and divided into three equal areas which are marked –, O, + respectively.

The trichotomy is exhibited in the accompanying Diagram IV.

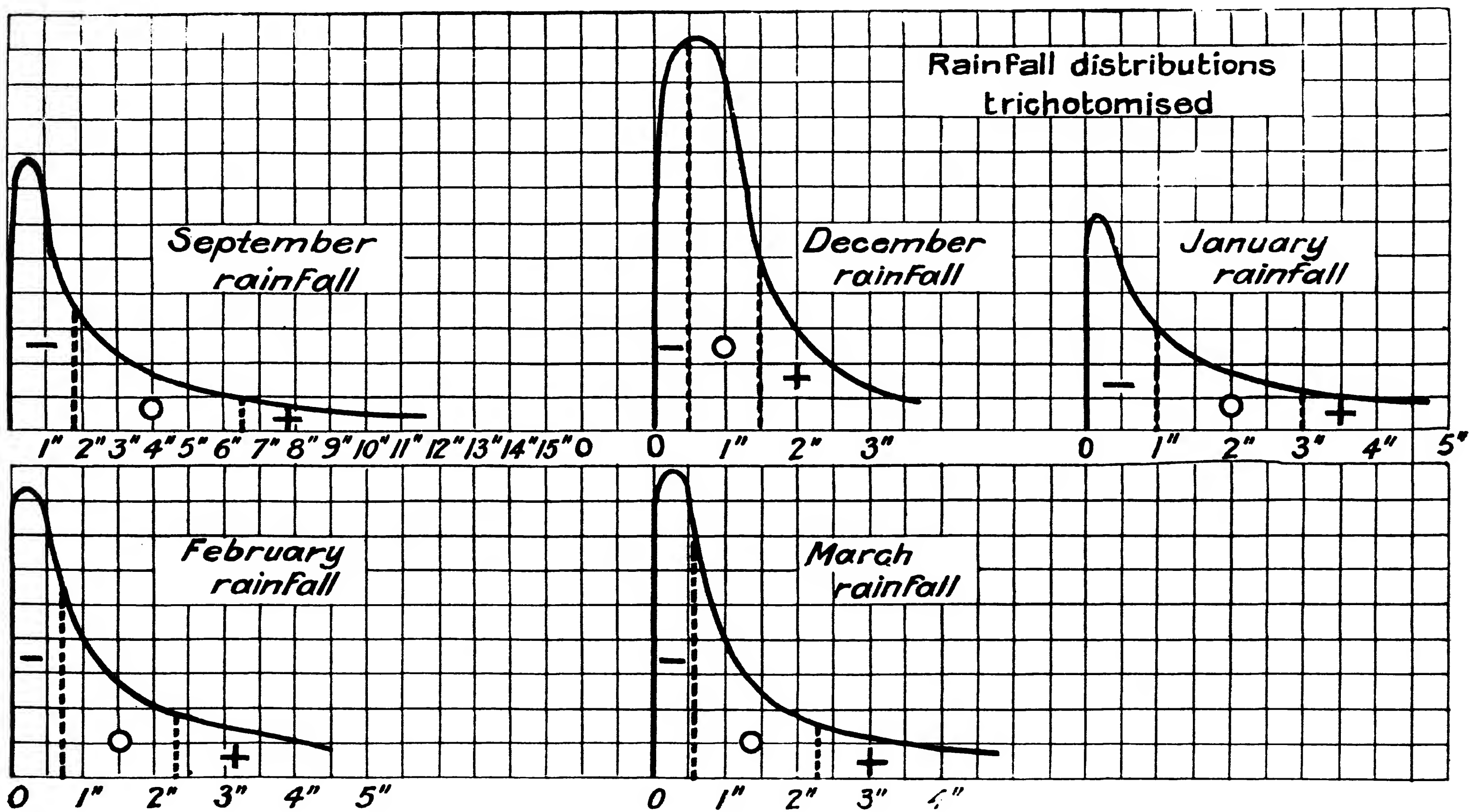
Thus :—

		–	0	+
		Less than	Between	Above
September	...	1″·8		6″·5
October	...	0″·1		0″·5
November	...	0″·1		0″·5
December	...	0″·5		1″·5
January	...	1″		3″
February	...	0″·7		2 ·3
March	...	0″·6		2″·2

Rainfalls in each month are then weighted according to the following scheme (September rainfall weight = 5).

Rain departure for September	Benefit of October and November rain
+	0
0	0
–	20
	Benefit of December rain.
+	1
0	2
–	3

DIAGRAM IV.



Rainfall distributions
trichotomised
September
rainfall
December
rainfall
January
rainfall
February
rainfall
March
rainfall
1" 2" 3" 4" 5" 6" 7" 8" 9" 10" 11" 12" 13" 14" 15" 0
0 1" 2" 3"
0 1" 2" 3" 4" 5"
0 1" 2" 3" 4" 5"
0 1" 2" 3"

	Rain departure December	Benefit of January rain
+	+	1
	0	2
	–	3
0	+	2
	0	3
	–	4
+	+	3
	0	4
	–	5

		Rain departure January	Benefit of February rain
+	+	+	1
		0	2
		–	3
	0	+	2
		0	3
		–	4
	–	+	3
		0	4
		–	5
0	+	+	2
		0	3
			4
	0	+	3
		0	4
		–	5
	–	+	4
		0	5
		–	6
–	+	+	3
		0	4
		–	5
	0	+	4
		–	5
		0	6
	–	+	5
		0	6
		–	7

The only modification which was necessary to this was the addition of the factor 20 to every 0 above 2 in number occurring in the months September, December, January, February and March, thus indicating that long continued normal conditions are, as in the case of cotton in Texas, very favourable.

The weighted rainfall in each month was added together, and a coefficient of benefit B obtained, and this was correlated with the area of unirrigated wheat for 1900-1915. The correlation is -0.91,

even higher than Kincer's figure of 0·88. The formula giving the percentage of failure in terms of the coefficient B is

$$K = 24{\cdot}2 - {\cdot}35B.$$

The *kharaba* calculated from this formula is plotted with the actual figures of *kharaba* in Diagram V. I think the agreement of the two values shows that the formula is a very good one and affords *a posteriori* justification of the hypothesis.

The introduction of suitable corrections for other climatic factors, such as temperature, sunshine, evaporation, precipitation in the form of dew, wind and the like would improve the prediction still further.

BETTERMENT OF PREDICTION.

Subsoil water. The method of correlation is not a method apart, dissociated from other methods of analysing observed facts; on the contrary, the more physical and chemical laws we can make use of before we start correlating the better.

For example in forming the prediction equations for sown areas, we have correlated rainfalls in August, September, and October with the areas sown in September, October, and November, but what we really want to know is, what the cultivator has a shrewd knowledge of, when he puts in his crop, and that is the state of the subsoil moisture, and also the temperature of the seed bed.

The problem is, given the rainfall and temperature throughout the monsoon period, what is the distribution of the subsoil moisture when *rabi* sowings commence. I have been unable to find even in Leather's valuable researches the complete answer to this question. He has indeed shown,* that if evaporation is an exponential function of the time, the quantity of water in the first seven feet of Pusa soil can be found from the known temperature and humidity from September till June, but as the question of run-off, which in the monsoon is all important, is not quantitatively worked out, it does not seem possible to apply the results without further

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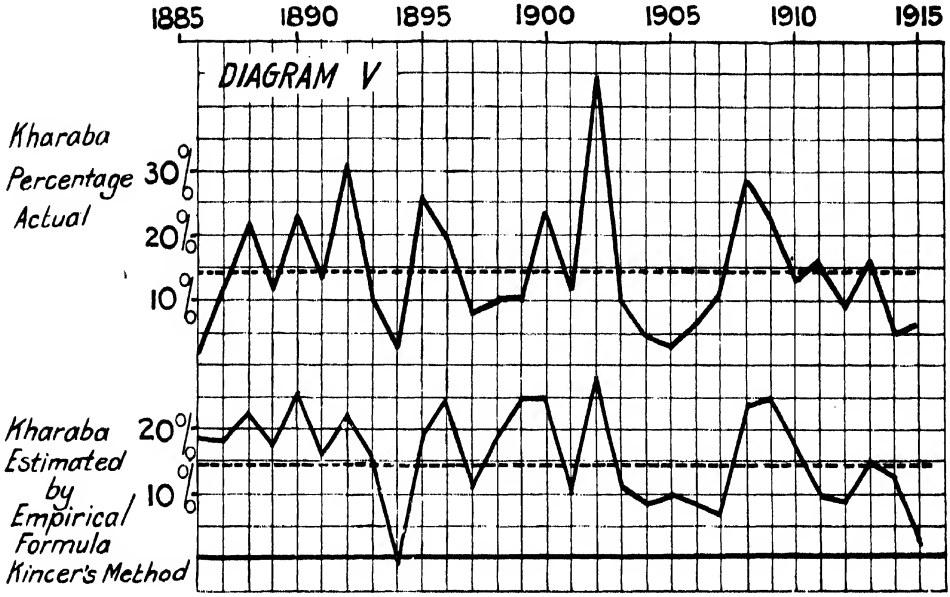
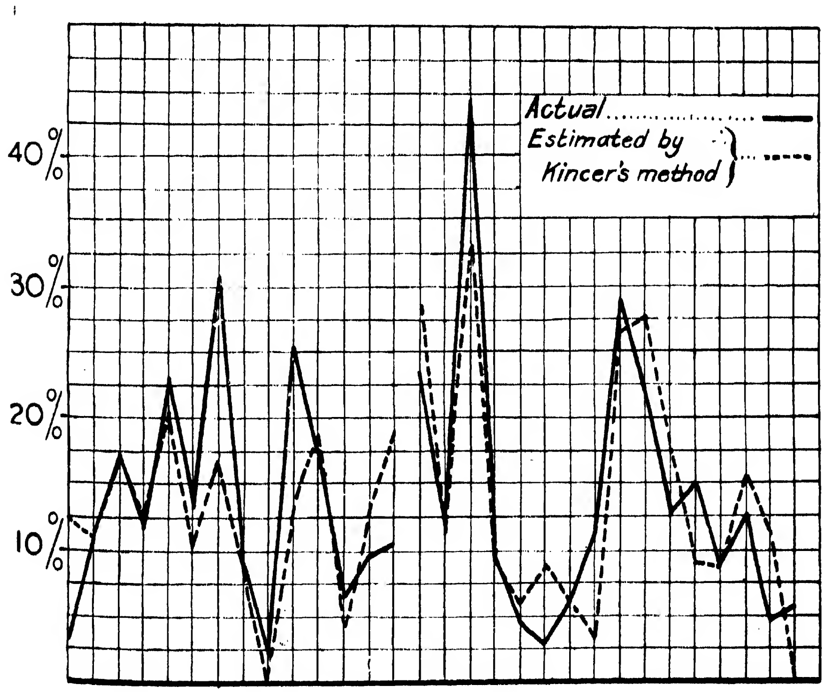
* Leather, J. W. Water requirements of crops in India. *Mem. Dept. of Agri. in India Chem. Ser.* vol. I, no. 8.

Dona Charhda WHEAT KHARABA.



WHEAT KHARABA.



experiment to the Punjab. It seems very desirable to repeat the Pusa experiments in all typical Punjab districts, and it should be possible as a result of them to state once for all a formula giving the soil moisture at the close of the monsoon, for each foot of subsoil in terms of the antecedent rainfall and the size and nature of the particles composing the soil.

The complete hydrodynamical solution of the movement of the subsoil water has not so far been obtained, but on the assumption that the velocity is proportional to the first differential of the relative saturation of the soil and that the ratio of surface of all particles per unit of volume to the saturation quantity of moisture is constant, an integrable equation results, for a linear change of particle surface with depth.

This is a great limitation. Further experiment in this country is urgently required, and from a sufficiently extended series of data assumptions could be made leading to a more or less accurate general solution.

Lastly as to the determination of yield, what we want to know is not merely what are the optima conditions of soil moisture and temperature, but what effect defective conditions have. Thus want of water in the first stage of growth is said to mean short stalk, but not necessarily small grain; in the later stages water is essential for grain development.

What is the quantitative expression of this law ?

According to Warren Smith, American corn requires between 40 to 80 per cent. of the saturation value of moisture for its most favourable development, but exactly what will be the development of a plant which has, say, 40 per cent. of moisture in one month, 30 per cent. in the next, 20 per cent. in the next, 30 per cent. in the next, and so on ?

In particular, what in each stage of development is the minimum requisite to support plant life.*

---

* Leather's researches throw some light on this problem, Vol. 1, No. 8 of the *Memoirs of the Department of Agriculture in India*, page 146, which shows that for unmanured wheat, an increase of soil moisture from 10 to 20 per cent. increases the grain weight by about 80 per cent.

(*Continued on page* 102).

Plant development. To sum up, the method of correlation enables us to establish prediction formulæ of both sowings and yield, which represent with accuracy the effect rainfall has on the crops. They would undoubtedly be improved by considering the effect, in particular, of prices, crop rotation and temperature, and by incorporating all established quantitative laws as to subsoil moisture and plant development. Even as it is, the formulæ obtained in this paper have a definite practical value which modern statesmanship cannot afford to ignore.

Conclusion.—In conclusion I wish to express my thanks to the kindness of Dr. Gilbert Walker and Dr. Simpson in having most of the many coefficients of correlation calculated.

Between 10 and 20 per cent. the weight of crop increases nearly in a linear fashion with increase of moisture, but though in the case of unmanured wheat diminution of outturn might be linear down to zero moisture it is certainly not so for Leather's experiments in the case of manured wheat, and in particular it is important to know what happens with greater saturation than 20 per cent. Even this preliminary knowledge for a pot culture with a percentage saturation kept constant throughout the period of development, would give a function closely correlated with the actual yield.

DIAGRAM VI.

DONA CHARHDA (Rabi Crops Sown.)

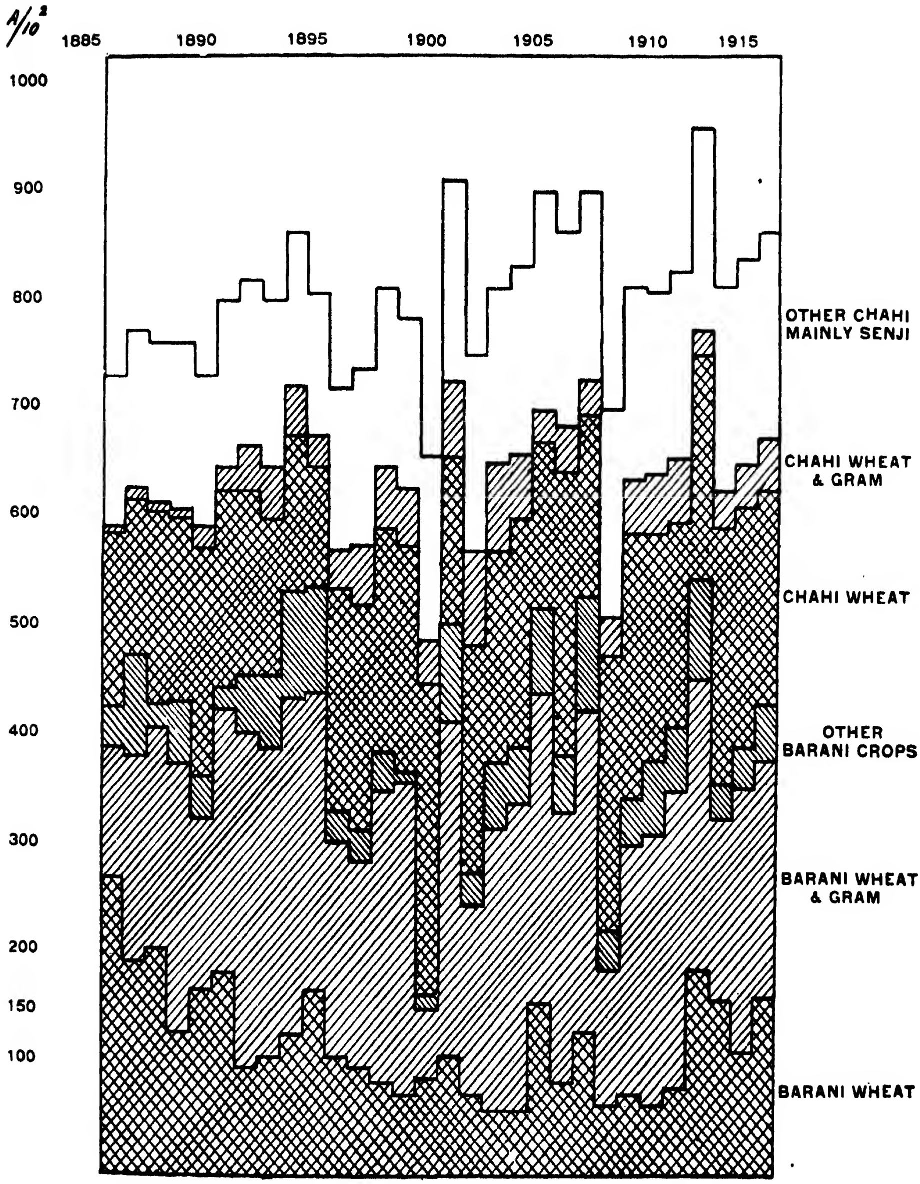


DIAGRAM VII.

Dona Charhda. (RABI CROPS SOWN)

PERCENTAGE OF EACH KIND OF CROP.

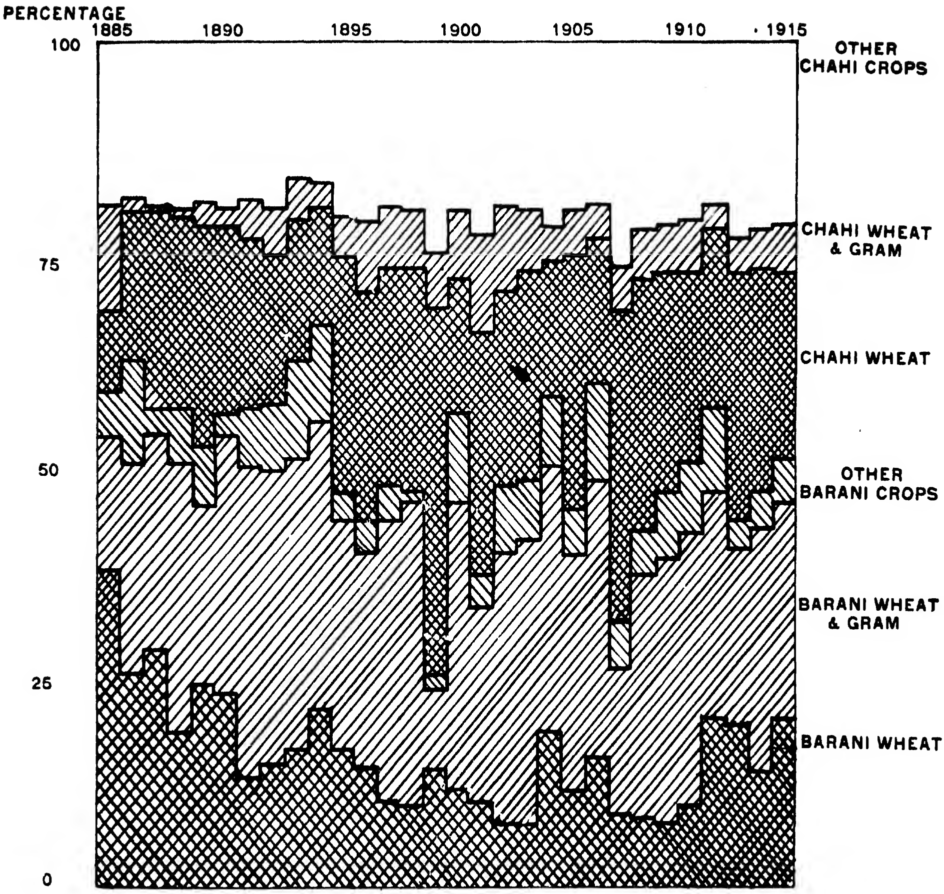
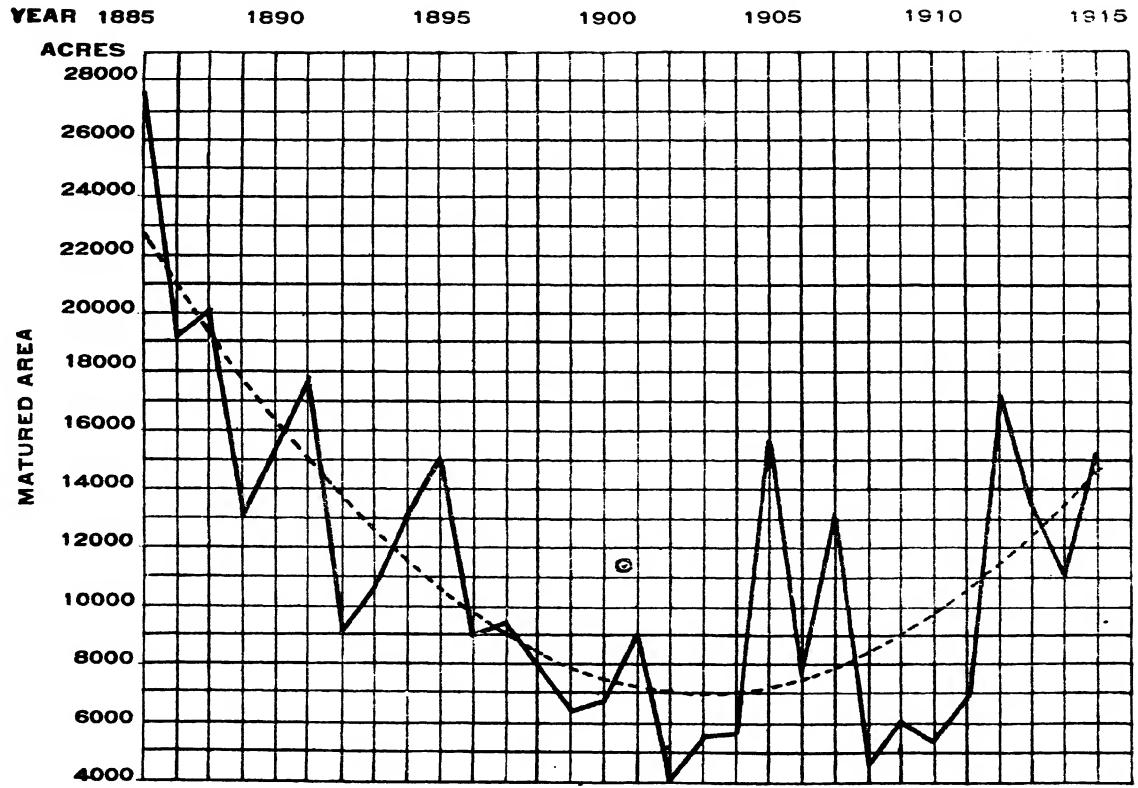


DIAGRAM VIII.

DONA CHARHDA CIRCLE JULLUNDUR TAHSIL

UNIRRIGATED WHEAT



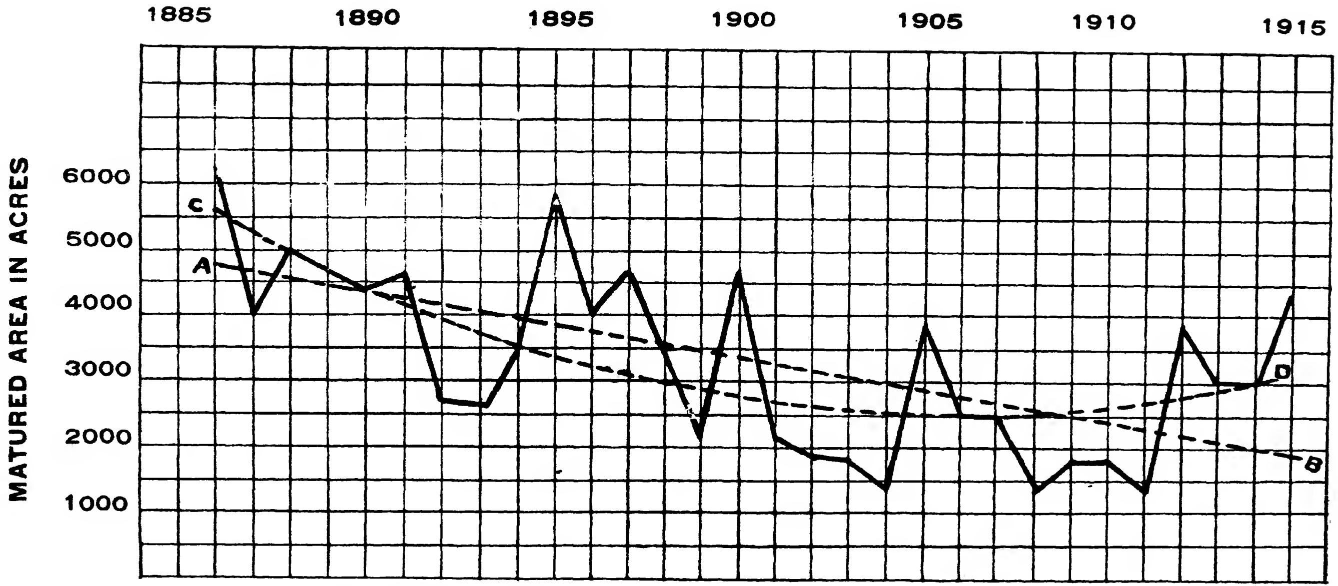
THE EQUATION OF THE PARABOLA OF CLOSEST FIT REFERRED TO THE CENTRE AS ORIGIN IS

$Y = -2{\cdot}01 - 0{\cdot}27X + 0{\cdot}108X^2$

DIAGRAM IX.

DONA LEHNDA CIRCLE JULLUNDUR TAHSIL

UNIRRIGATED WHEAT



AB IS THE STRAIGHT LINE OF CLOSEST FIT.
CD IS THE 2ND ORDER PARABOLA OF CLOSEST FIT.
THE EQUATION OF AB REFERRED TO CENTRE OF THE RANGE IS
$Y = -\cdot 20\ 2x$, AND OF CD. $Y = -\cdot 56 - \cdot 17x + \cdot 03x^2$.
THE LINE OF CLOSEST FIT IS EQUIVALENT TO A DECREASE
OF 100 ACRES PER ANNUM.

DIAGRAM X.

SIRWAL BARANI WHEAT.

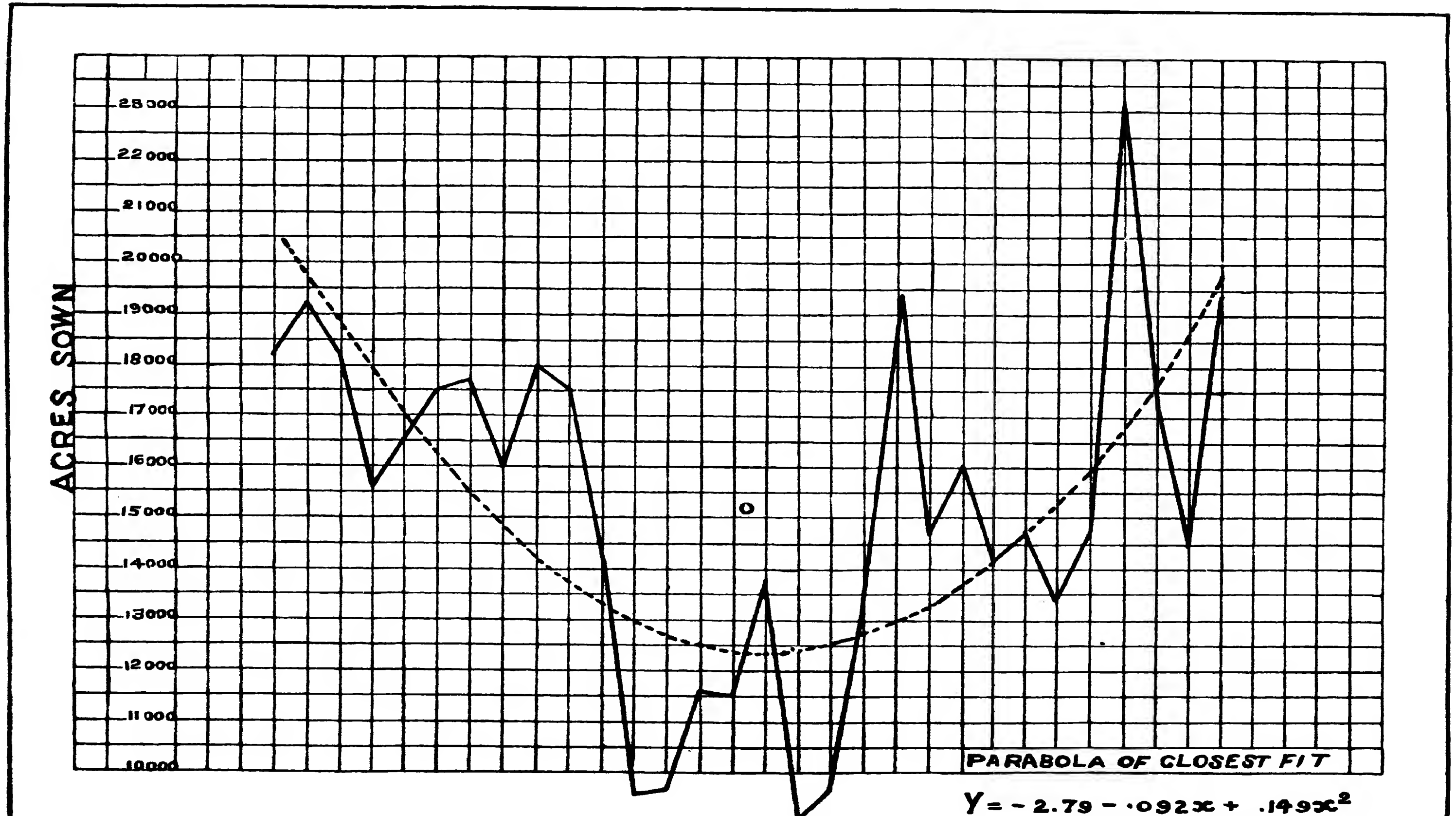
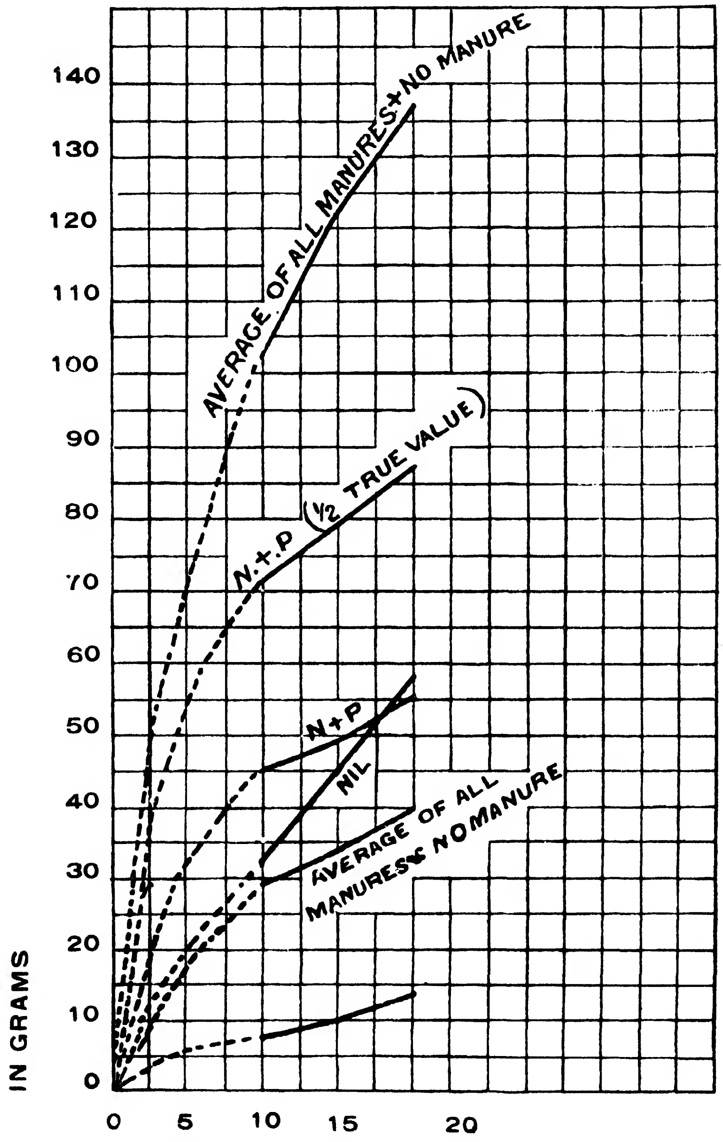


DIAGRAM XI.

EFFECT OF SOIL SATURATION ON YIELD OF WHEAT



N= CaCN2 P= SUPERPHOSPHATE

THE LOWER SOLID LINE IS THE AMOUNT OF SEED,

THE UPPER SOLID LINE IS THE TOTAL DRY CROP.

DOTTED LINES GIVE ASSUMED INTERPOLATIONS

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